RUDIMENTS OF REFRACTION

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— OF —

REFRACTION

A REPRINT OF A SERIES OF PAPERS ON

REFRACTION

ORIGINALLY PRINTED IN PHYSICIAN'S DRUG NEWS AND OFFICE PRACTITIONER

WRITTEN AND REVISED BY

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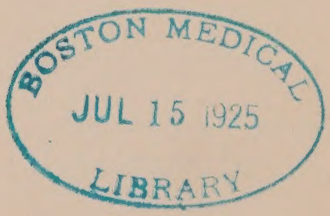
NEWARK, NEW JERSEY
THE PHYSICIANS' DRUG NEWS COMPANY
250 HIGH STREET



PUBLISHERS' NOTE.

The preparation of this series of papers was begun by Dr. Button at our request because we felt that physicians should become more familiar with the subject.

The aim throughout has been to make the papers as brief and simple as possible. The busy physician has little time to spend upon theory, what he wants is something practical. The author has endeavored, and we believe succeeded, in producing a really practical work on refraction.

The papers have been received so favorably by the readers of Physicians Drug News that there has been a demand for the complete series which we could not supply. We have undertaken their publication in this permanent form that thousands of other physicians may thereby be benefited.

THE PUBLISHERS.

Newark, N. J., August, 1911.

PREFACE.

The series of papers originally written for The Physicians Drug News, and which have been reprinted to form this little book, were not designed as an exhaustive treaties on refraction, nor was it intended to discuss the science of Optics.

Nearly all books on the subject devote considerable space to the anatomy and physiology of the normal eye, and to the study of optics as used in correcting ametropia.

While this is the proper way to begin the study of refraction, many a busy practitioner has too little time to work out the problems from cause to effect, and wants the stated facts, together with the practical application of refraction to the correction of visual defects. Hence these papers which were designed to give sufficient information for the practical refraction of ordinary cases, with the minimum amount of reading, leaving it for the doctor to study optics at his leisure, from any of the numerous works on that subject.

The Editor of Physicians Drug News and Office Practitioner, has kindly reprinted the revised papers in book form for the convenience of its readers, and that they may be obtained by those who did not take the Journal while they were running. That they may be helpful to others is the sincere wish of,

THE AUTHOR.

Holland, N. Y., 1911.

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Rudiments of Refraction

In submitting the following chapters on refraction to readers of the Drug News, it is not intended as a scientific discussion of the subject, or one that will be interesting to experts in the work. We will simply try to give something of practical use to General Practitioners who may desire to do refracting. In small towns, where there is no oculist, it is desirable that the family physician know something about visual defects and refraction, in order to make diagnosis as to whether defective vision exists or not, and perhaps refract and prescribe for some clear cut simple cases, even if he can not take the time to refract those that are more difficult.

Much can be taught by text books, lectures, and articles written on the subject, but it takes actual practise to become proficient. One may practice refraction a great many years and still he will frequently learn something new from experience.

It has been stated in medical journals that physicians in general practise ought to be able to do refraction of simple cases at least. This sounds easy, but it is often a difficult matter for one with considerable experience to decide on the kind of defect and whether the case is simple or not. By simple cases the writer probably meant those cases in which there is no astigmatism.

Simple and Complex Cases.

In order to get a fair idea of the proportion of simple to complex cases, one hundred cases have been taken as they run on my record book, with the following result:

Presbyopia	14	
Hyperopia	17	
Myopia	9	40
Hyperopic Astigmatism	22	
Compound Hyperopic Astigmatism	17	
Myopic Astigmatism	11	
Compound Myopic Astigmatism	2	
Mixed Astigmatism	8	60
		100

Presbyopia, (the loss of accommodation,) does not usually occur in sufficient degree to require glasses before forty-five or fifty years of age, and it is simple and easy to fit. If it occurs before the age of forty-five, as it occasionally does, it is usually in a person with defective vision for distance; after the distant vision is corrected, the correction for the loss of accommodation is simply the addition of a spherical of sufficient power to focus at the reading point. Hyperopia and myopia are not hard to fit in themselves, but it is often hard to decide whether there is any astigmatism present or not.

All forms of astigmatism are somewhat difficult to fit, and mixed astigmatism is the hardest of them all.

There is a wide difference in patients regarding the ease with which they are fitted. Two patients with the same form of defect, one may be easy to fit and the other very difficult; due to the difference in their nervous condition, the sensitiveness of the eye to a change of lens, and the control the patient has over the action of the ciliary muscle; some can be easily fitted without drops, while others can not be correctly fitted until cycloplegia is produced.

Who Should Do Refraction.

In view of the foregoing the question arises, when is it advisable for a doctor in general practise to attempt refraction?

This question can not be directly or positively answered; it depends on the consideration of several associated factors, among which are the following:

1. Is it necessary or desirable, a—on account of no resident oculist, (oculist, not optician, is meant); b—Is the cost by way of the oculist too great a burden for many of his patients?

2. Has he the room and can he take the time necessary to do refracting?

In considering proposition 1-a, there are very few small towns in which an oculist is located; occasionally a physician who has done eye work in general practice, will confine his practise to office work and make a specialty of refraction; but usually the work is done by opticians who, though they may be well posted in optics, know practically nothing about the physical condition of the patient, nor are they able to diagnose disease in other parts of the body to which the defective vision may be due. They are also quite liable to error in those cases where a cy-

cloplegic should be used. Hence. where there is no oculist, it is desirable that the family doctor understand refraction.

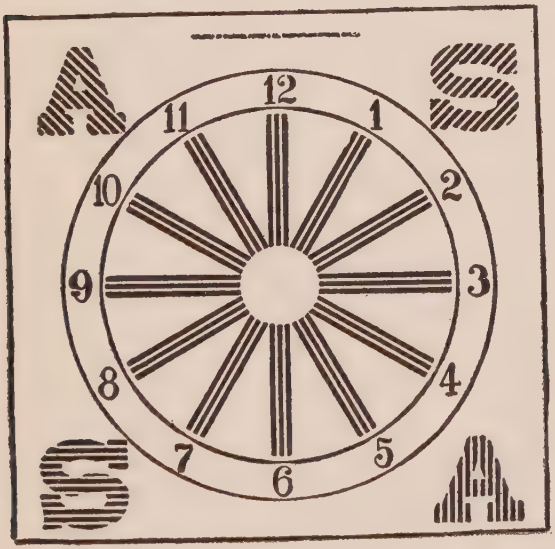


Fig. 1.

As to proposition 1-b, if the oculist writes a prescription to be taken to an optician for the glasses, then his fee plus the bill of the optician may make it too expensive for many of the doctor's patients, and thus make it desirable for

him to do refracting, even in a small town where there is an oculist. Then again the oculist may have wholesale rates with manufacturing opticians and furnish the glasses prescribed; he can then let a part of the profit on the glasses apply on his fee, and thus cost his patient less. Where this is done, it might be better in many cases for the general practitioner to give him the work.

Proposition 2 is an important factor to consider. An average of an hour will be required for each case in addition to an hour for instilling the mydriatic where one is required. If one has an office girl she can be taught to use the mydriatic when one is necessary, then the doctors time will only be taken during the refracting. Some cases may be fitted in less than an hour, and many will require a longer time. The more experience one has the more rapidly he can refract, but it takes considerable time at the best to do good work, and unless the time necessary to do good work can be given, he better not attempt refraction.

As to room, it is desirable to have twenty feet in a straight line for the card of test type, astigmatic chart, and a light. The office is seldom that long, but this distance can usually be obtained by hanging the cards in the wait-

ing room and seating the patient at a point in the office where he will be in line with it through the open door. Test letter cards have letters for use at fifteen and ten feet distance. There are also mirror arrangements whereby the required distance may be obtained in a small room; but they are all inferior to the direct twenty foot distance.

Equipment.

Providing the physician decides to do refraction the next question that arises is the equipment required.

He should have a case of testing lens containing at least:

Plus sphericals from 0.12 to 10. diopters.
Minus sphericals from 0.12 to 10. diopters.
Plus cylinders from 0.12 to 4 diopters.
Minus cylinders from 0.12 to 4 diopters.
Prisms from ½ to 10 degrees.
1 Maddox's rod.
1 Chromatic test.
1 Stenapaic disc.
1 Pinhole disc.
1 Solid rubber disc.
1 Adjustable graduated trial frame.

Trial cases, varying in their contents, are

made up by optical houses, and most of them contain more than the foregoing enumeration; but the one selected should contain every one of the articles herein mentioned; they are all necessary.

He will also need:

1 Retinoscope with a ¾ inch plano (flat) mirror.

1 Card test type for distance.

1 Card test type for near work.

1 Astigmatic chart with lines running at 30'', 60'', 90'', 120'', 150'', 180 degrees.

1 Astigmatic chart with two sets of lines running at right angles with each other like the sign plus, and on a circular card, attached with a fastening in the center to a second larger card that is marked and numbered like the face of a clock; so that one of the sets of lines can be set at any desired angle, and the other set will run at right angles to it. Then when the axis of the astigmatism is found, the cross can be set, and just the lines wanted will be visible with no intermediate lines to bother.

The adjustable trial frame is intended for taking face measurements for frames; but it will be found more convenient and accurate to have three ordinary steel frames.

One with bridge height ¼ inch, crest on plane with lens.

One with bridge height ⅛ inch, crest 1-16 back of plane of lens.

One with bridge height 1-16 inch, crest ⅛ back of plane of lens.

A nose crest measure for getting the angle of crest of bridge, and a small six inch rule marked in inches by sixteenths on one edge and in millimeters on the other edge.

Also one small record book about 3¼x5½ in which to keep a full record of cases fitted. (This size will fit in most trial cases, and a page is about right for one record.)

A book of duplicate prescription blanks for keeping a manifold copy can be obtained at optical houses.

An illustrated general catalogue from some manufacturing optical company would give much information toward helping to select an outfit.

The foregoing list is sufficient to enable one to do good work, and every article therein named is needful, regardless of what other equipment is purchased.

There are many other helps that aid in correcting visual defects which are convenient and often shorten the time required for fitting.

They are useful if one has the money to spare for them, and the room in which to keep and use them; but the final checking up and confirming of results should be done with the test lens, and other accessories herein named as necessary in an outfit.

A skiascopic eye on which to practise the shadow test with the retinoscope is a useful educator.

The technique of the equipment will appear in subsequent chapters, when discussing the diagnosis and correction of various visual defects.

The science of optics can be studied in detail and at will from works upon that subject, and only that part applied to the fitting of the eye, and with which our readers are probably familiar, will be mentioned here.

Refractive Media.

When a ray of light enters a more dense medium at an angle to its surface, as A-B, it is bent toward a line perpendicular to its surface, as B-C.

Also a ray of light entering a more dense medium in the form of a prism, is deflected toward the thicker part, or base of the prism; and the thicker the base the greater the deflection.

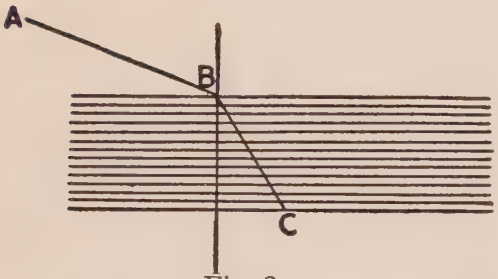


Fig. 2.

In order to have perfect vision, all the rays of light entering the eye must be refracted to focus exactly on the retina. The refractive media of the eye consists of the aqueous humor, the crystalline lens, and the vitreous humor; all of them more dense than air, with the crystalline lens acting as a prism. Rays of light entering the eye first meet the aqueous humor and are slightly refracted; they next pass through the crystalline lens, which is an adjustable double convex body, and are refracted more or less in accordance with its adjustment; thence they enter the virtreous humor and the refraction is continued until they reach the retina.

The crystalline lens is equal to a circular prism with the center as its base; it is held stretched to this prismatic form by the suspen-

sory ligament; the ciliary muscle surrounding the lens is so attached that when it contracts it releases the suspensory ligament in proportion to the amount of its contration, and the elasticity of the lens causes it to assume a more convex form, thus increasing its refractive power. The ciliary muscle is controlled by the ciliary nerves which branch from the ophthalmic division of the fifth; the ciliary nerves have a little ganglion of their own, and are so connected with the optic nerve and sympathetic system that under their control the ciliary muscle acts to change the lens to a more or less convex form, thus increasing or decreasing its refractive power as necessary to maintain the focus on the retina, just as rapidly as the eye can change from near to distant vision.

This process of changing the form and refractive power of the lens is called accommodation; and the exercise of the accommodation in an effort to obtain perfect vision in a defective eye is the keystone in the arch of eye-strain, with its varied physical effects on the patient resulting through the sympathetic nervous system.

The power of accommodation gradually grows less as age advances, but it is sufficiently active up to fifty years of age to require care-

ful consideration when fitting a defective eye. Often through exercise of the accommodation the patient will adjust the eye to each lens put before it, so that it is difficult to tell when any improvement is made, or the correction accomplished. In some nervous subjects it is hardly possible to make the proper correction without producing cycloplegia.

There are many points about the part that the accommodation is playing in the correction, which will be given in future chapters on the technique of refraction.

The more experience one has, the better he can overcome the obstacle of accommodation without the use of a cycloplegic.

SECOND PAPER.

Test Letters And Recording Vision.

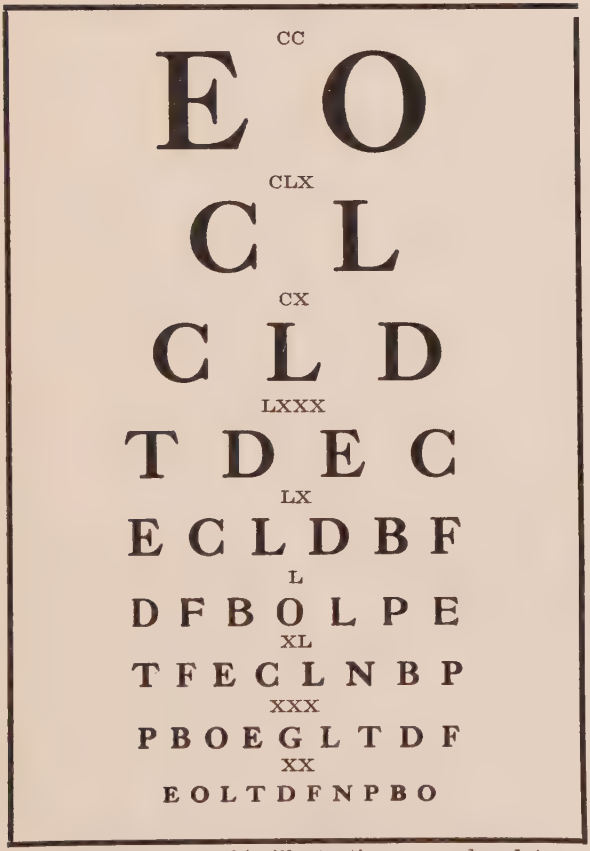
The letters on the cards of test type are so constructed in regard to the angles and refractive media of the eye that the letters numbered XX can, in a good light, be easily read by a normal eye at twenty feet distance; those numbered XL at forty feet, and those numbered LXXX at eighty feet. The letter to be read at forty feet will be found on measurement to be just twice as large as the one to

read at twenty feet; and the one to read at eighty feet will be four times as large as the one at twenty.

Cards made by different optical firms sometimes have different letters, with the distance differently marked; but they are all on the same principle.

Snellen's test type with the distance marked by feet in Roman characters is in use in my office, hence it is the kind that will be referred to in this article.

In recording a patients vision the distance between the patient and card is taken for the numerator of a fraction, and the smallest type that can be easily read at that distance is taken for the denominator. The eyes are designated as L. E. V. for left eye vision, and R. E. V. for right eye vision. O. S. (Oculus Sinister), for left eye, and O. D. (Oculus Dexter), for right eye, are frequently use in place of the foregoing abbreviations. With the patient seated twenty feet from the card, we slip the solid rubber disc into the trial frame over the right eye and find how far down the type on the test card can be easily read, telling the patient not to strain the eye; we find it to be the type marked XL, and we record the vision of the left eye thus: L. E. V. 20-40. We then cover



The letters on this illustration are reduced to about one-seventh of the size of letters to be used at the distances designated.

Fig. 3.

the left eye with the solid disc and test the right eye vision in the same way, and find that the type marked LXXX is the smallest that can be easily read. We record the vision of the right eye, R. E. V. 20-80. This means that the patient must be within twenty feet of a certain size letter to read it, whereas one with a normal eye would read it at eighty feet distance. It does not really mean that the patient has only one fourth normal vision for practical purposes, but the fraction relates to the refractive media and visual angles of the eye, and is relative as regards acuity of vision. The initials and fraction make a record that can be read and understood by any oculist. If the largest letters can not be read at twenty feet, bring the card near enough to read the letters numbered CC, and make 200 the denominator and the distance the numerator; if it had to be brought to fifteen feet distance, we would have 15-200 as the record. Or the distance may be ascertained at which fingers can be accurately counted, and recorded as, fingers — feet.

The cards usually used have black letters on a white background; since white is a reflection of all the rays of light, and in black they are all absorbed, many prefer a black background with white letters, thinking it less tiring to the eyes.

Astigmatic Charts.

When giving a list of the equipment required it was stated that two astigmatic charts are advisable. The one with lines running at angles of 30″, 60″, 90″, 120″, 150, and 180 degrees, is used in connection with the subjective symptoms of the patient and other tests to determine whether there is astigmatism present or not, and if so, its probable approximate axis. It is not reliable in its-self alone, either to the fact regarding astigmatism, or as to its axis. One patient may say that certain lines look more distinct than those at right angles to them, thus indicating astigmatism, when really none exists; while another may say that the lines all look equally distinct, thus indicating that the eye is not astigmatic, and upon refraction astigmatism will be found. This difference is due to muscular action on the eye in straining it, and to difference in the nervous condition of the patients. Hence the astigmatic charts though a valuable aid, cannot be depended upon alone. Further discussion of their use in conjunction with other tests will be given in the technique of diagnosis and correction of astigmatism.

Some charts with lines running as herein stated will be found with the degrees number-

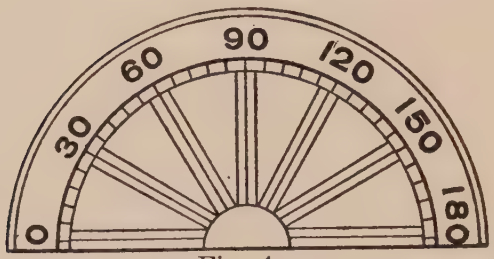


Fig. 4.

ed from right to left; this is not right; they should be numbered from left to right; and whether numbered or not, that is the direction in which the refractionist must count them. The trial frame is numbered from right to left, and since the patient and chart are facing each other, in order to have the number of degrees on the chart correspond with the axis given on the trial frame, they must be numbered in opposite directions. If the lines seen most distinctly on the chart are at the left of 90 degrees, the axis will be found to be less than 90 degrees; and the two will correspond if the chart is numbered from left to right, but will not if numbered from right to left.

The other astigmatic chart with two sets of lines running at right angles with each other, and described as contained on a circular card which is attached at the center, so it can be re-

volved, to a second larger card with a larger circle marked and numbered like the face of a clock, is to use as an aid in the correction of astigmatism after it has been diagnosed and its axis found. The card is revolved until one set of lines corresponds with the axis of the

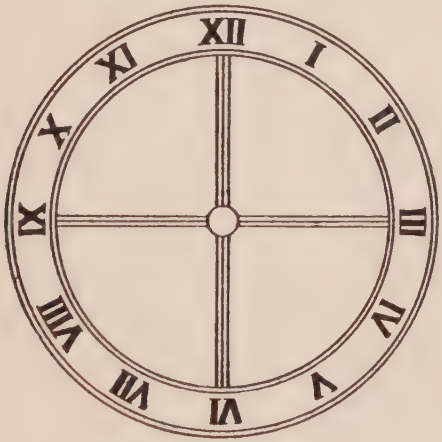


Fig. 5.

astigmatism; then the other set of lines run at right angles for comparison, and there are no intermediate lines to confuse.

Light and Position of Chart.

The card of test letters and the astigmatic chart should be placed where a good light will

illuminate their face. Natural light is preferable, but if a good natural light cannot be obtained, an artificial light can be used. If artificial light is used, it should be so placed that it will light the card nicely and at the same time be hidden from the patient; this can be accomplished by placing the light a little at one side of a line from the patient to the card, with a screen to hide the light from the patient.

The astigmatic chart, or at least the cross that is used to aid in correcting the astigmatism, should hang at a level with the patient's eye, or nearly so.

Discussion of the test letters and astigmatic chart at this time, is in order that future reference to them may be clearly understood. Details regarding the various points, axis, and angles of the eye, which are a basis for the formation of the test letters and astigmatic charts, may be found in scientific books on optics and refraction, to which the reader is referred for information that is interesting and useful. The scope of this paper is to give simple facts and directions that will be of immediate practical help to the beginner in refraction, leaving the scientific part to be studied at leisure.

THIRD PAPER.

Nomenclature of Visual Defects.

Normal and defective eyes are known and referred to under different names depending on the kind of defect; with these terms the refracting doctor should become familiar.

Emmetropia.—An emmetropic eye is one in which the refraction is normal.

Ametropia.—An ametropic eye is one in which the refraction is abnormal.

Hypermetropia, also called Hyperopia.—This condition is one in which the rays of light focus beyond the retina, due either to a short anteroposterior diameter, or to a subnormal power of the refractive media of the eye.

Myopia.—In this condition the anteroposterior diameter of the eye is too long, and rays of light come to a focus in front of the retina.

Astigmatism.—An astigmatic eye is one in which the surface is more convex and the refraction greater in some one meridian of the eye than in the meridian at right angles to it. There are several kinds of astigmatism.

Hyperopic Astigmatism is a condition in which the rays focus on the retina in one meridian, while in the meridian at right angles thereto, the surface of the eye is less convex

and the rays passing through it focus beyond the retina.

Compound Hyperopic Astigmatism.—In this condition the rays all focus beyond the retina, but in one meridian they focus farther beyond than in the meridian at right angles to it.

Myopic Astigmatism.—Here the rays in one meridian come to a focus on the retina, while the rays in the meridian at right angles focus short of it.

Compound Myopic Astigmatism.—In this form the rays all focus short of the retina, but in one meridian they focus shorter than in the other.

Mixed Astigmatism.—This is a condition in which in one meridian of the eye the surface is more convex than normal, and rays focus short of the retina, while in the meridian at right angles thereto the surface of the eye is less convex than normal, and rays come to a focus beyond the retina.

The illustrations in which the white disc in the posterior part of the eye represents the retina and the heavy lines represent rays of light in one meridian of the eye, and the light faced lines rays in the meridian at right angles, will help to make these various conditions clear.

Fig 6.

Astigmatism is also designated as regular and irregular with the rule and against the rule, symmetric and unsymmetric.

Regular Astigmatism, is the usual form, in which the meridians of the greatest and least curvature are at right angles to each other.

Irregular Astigmatism, is a rare form due to the effects of disease or surgery, and in which the meridians of greatest and least curvature are not at right angles to each other, and in which different sections of the same meridian may not have the same refractive power.

Astigmatism With the Rule, is where the axis is hyperopic astigmatism is at or near 90 degrees, and in myopic astigmatism at or near 180 degrees.

Astigmatism Against the Rule, is where the conditions are just the reverse of the foregoing.

Symmetric Astigmatism is the form usually found. In it the axes of the two eyes added together make just 180 degrees. Thus, if the axis in one eye is 30 the other will be 150; or if one is 60 the other will be 120; or the axis may be 90 in each eye; the two combined making just 180 in each case. If the axis of both eyes are in the horizontal meridian, one eye is counted as 0 and the other 180.

Unsymmetric Astigmatism is occasionally en-

countered, and it is more troublesome to correct. It is a form in which the axis of the two eyes combined do not make just 180 degrees; but make more or less than 180. For instance, the axis of one eye may be 30 degrees and the other 120, making a total of 150 only; or each eye might have an axis of less than 90 degrees, making a total of less than 180, or again each eye might have an axis of more than 90, thus making a total of more than 180.

Chief Meridians, is a term applied to the most convex and the least convex meridians of the eye, and where the astigmatism is regular they are always at right angles to each other.

Further consideration of astigmatism will be given when we come to a discussion of its correction.

Presbyopia.—This is a condition in which the accommodation is impaired to a degree that requires glasses for near work.

Accommodation.

In discussing the refractive media of the eye in the first paper of this series, it was stated how, in the normal eye, the crystalline lens changes to a more or less

convex form, thus increasing or decreasing its refractive power, as often and as rapidly as is necessary to equalize the requirements of refraction for varied distances and maintain the focus of rays of light on the retina. This function of the crystalline lens as controlled by its muscles, ligaments, and nerves, is called accommodation. The range of accommodation begins to grow less early in life; the loss is gradual and usually, though not always, it does not reach a point of inefficiency until at from forty-five to fifty years of age.

At about fifty years of age the lens has lost its elasticity to a degree that when the suspensory ligament is released through the action of the ciliary muscle, the lens will not assume a sufficiently convex form for near work, and a weak convex glass is required to make up what the lens lack in supplying. As age advances the lens looses its elasticity more and more, and an ever increasing strength of glass is required. This defect is called presbyopia as herein defined.

Muscular Action.

Closely allied to eyestrain with its train of symptoms, and which must be considered by

the refracting doctor who would relieve his patient, is nerve strain due to unbalanced muscles. From anatomists we learn that in addition to the ciliary muscle and those of the iris, each eye has six special muscles, each one of which, together with its opposing mate, controls certain movements of the eyeball.

The superior oblique, inferior oblique, superior rectus, and inferior rectus, seldom cause trouble that requires attention. The internal rectus which rotates the eye inward and the external rectus which rotates it outward are the muscles that frequently give symptoms from eyestrain through their imbalance. Some of these muscles are often called by names significant of their action; as, the superinor recti, the elevators; the inferior recti, the depressors; and the internal recti, the converging muscles.

Like muscles of the two eyes act together in harmony; this does not mean that the action of the pairs are always just the same, but they act in harmony to produce the desired result. The elevators and depressors act in unison to rotate the eye upward or downward; so the converging muscles act in unison to rotate both eyes inward, equally; but if the eyes are turned to the right or the left,

the internal rectus contracts in one eye while the external rectus contracts in the other eye; here they act in harmony to gain the desired end, but the action of the indiviual muscles composing each pair are different. Each muscle has its opposing mate, the action of one being just the reverse that of the other; and all of them when at rest are in a state of feeble contraction.

When it is desired to move the eyes in any direction, the pair of muscles for that special purpose, under influence of their innervation with an increase of nervous energy, contract sufficiently to overcome their opposing mates and move the eyes to the point desired.

Insufficiency of Muscles.

In eyes with normally balanced muscles the strength of each in relation to its fellow is such that when at rest there is no muscle strain, and when in action the opposing muscle can be overcome and the eye moved and maintained in the desired position for a reasonable length of time without inconvenience or fatigue. But when one muscle is weak as compared with its opposing fellow, the extra nervous energy required to enable it to move

and maintain the eye in some desired position gives symptoms of eyestrain.

This weakness of a muscle as compared with its fellow is called muscular imbalance, or insufficiency of whichever muscle is weak.

The imbalance is due to their relative instead of their actual strength; for instance, the internal rectus should be three times as strong as the external rectus; in one case we will say that the former can overcome a prism of 6 degrees and the latter one of 2 degrees; these muscles are both weak, but they are balanced because their relative strength is in the right proportion, and no symptoms of eyestrain would ensue.

Again in another case we will say that the internal rectus can overcome a prism of 12 degrees and the external rectus one of 10 degrees; here both muscles are strong, but there is an imbalance because their relative strength is not right, and there would probably be symptoms of eyestrain at near work, due to a tiring of the muscles on account of insufficiency of the internal recti, and to the extra nervous energy required to maintain the eyes converged sufficiently to hold the visual axes at the near point.

There many be imbalance in any of the

muscles concerned in moving the eyeball, but an imbalance of the internal and external recti is the usual form encountered, and the only kind that is of sufficient practical importance to need discussion here. The external recti are taken at whatever strength they may happen to be, within reasonable bounds, and the strength of the internal recti compared thereto; if they do not measure up about three times as strong there is an imbalance due to a relative weakness of the internal recti; it is called insufficiency of the internal recti; it is also sometimes spoken of as insufficiency of the converging muscles. As to whether the imbalance will give symptoms of eyestrain or not depends on the degree of imbalance and the nervous condition and sensitiveness of the patient.

Muscular imbalance due to a weakness of one muscle as compared with its opposing fellow, is known in scientific nomenclature as Heterphoria; and some of its varieties are:

Exophoria, a tendency of the eye to deviate outward, due to a weakness of the internal rectus.

Esophoria, a tendency of the eye to deviate inward, due to a weakness of the external rectus.

Hyperphoria, a tendency to deviate upward.

Orthophoria, is a term given to perfect muscular balance. To measure the strength of the recti muscles, place a light at about twenty feet distance and at table height or more; seat the patient facing it and looking at it with both eyes. Begin with a low degree prism and place it before one eye, base in, and continue to change to prisms of higher degree until two lights are seen that can not be brought together; the highest degree prism that the patient can overcome and hold the light as one, is the measure of the external rectus muscle.

Now go through the same procedure with prisms bases out, and the highest degree that can be overcome and the light held as one, is the measure of the internal rectus.

A prism deflects rays of light toward its base; so when a prism is placed before one eye with the other eye uncovered and both looking toward a single light, the eye has to move away from the direction of its base, or double visions results; hence bases in measure the external recti and bases out the internal recti.

The insufficiency of an ocular muscle, with a tendency of the eye to deviate, is overcome through increased innervation, and perfect binocular vision is thus secured.

It is this extra expenditure of nervous energy that produces the symptoms of eye strain from muscular imbalance.

When the insufficiency is of too great a degree to be overcome by increased innervation, then we have actual deviation, or strabismus.

This defect also has a nomenclature for its different varieties, some of which are:

Orthotropia, is perfect binocular fixation.

Esotropia, is a deviation inward.

Exotropia, is a deviation outward.

Heterotropia, is applied to any decided manifest deviation. The difference between insufficiency and strabismus is one of degree. In the former it can be overcome by increased innervation, while in the latter it cannot. In the former we get the reflex symptoms of eyestrain, but not the disfigurement; in the latter the eye has given up the struggle and escapes the eyestrain to a great extent, but the disfigurement is manifest.

FOURTH PAPER.

The four usual ways in which the subject of refraction may be presented to the general practitioner for consideration are:

1st. The patient may complain of dimness

of vision, either for distance or near work, and perhaps for both.

2nd. There may be recurring or continuous disease of the eyes, in which refractive error is suspected as the cause.

3rd. The complaint may be that the eyes tire and ache when at close work, and that print seems to run together and becomes indistinct after reading a short time.

4th. The patient will complain of trouble in distant parts of the body, which may be reflex, due to eye strain.

Disease, Causing Dimness of Vision.

The first cause named as one to send the patient to the refractionist, is also one to call for a consideration of the various forms of disease that cause dimness of vision, and to which the patient's trouble may be due wholly or in part.

The history and the subjective symptoms of the case will usually give important information from which to judge whether the trouble is probably due to disease or to refractive error. If due to disease the history will usually show the disturbance to vision to be of recent occurance, or possibly the history will be one of recurring attacks with intervals during which the vision was much improved; while if due to refraction, the trouble will usually

have a history of long standing, or of having been noticed on a change of occupation to one that required more exacting use of the eyes. Then the objective examination will throw more light on the matter.

CONJUNCTIVITIS usually presents objective features by which it may be recognized at a glance. The trouble may be due to refractive error, constitutional source, local irritation, or infection. The eye is congested and red, the blood vessels are superficial, tortuous, and less marked near the cornea. There is usually a feeling as if something were in the eye. There is little if any photophobia, but the secretion is abundant, and the lashes are often matted together, especially mornings. Vision is but little affected, except as dimmed by the secretion. It is not advisable to attempt refraction tests until the eye is put into condition for it.

Always, before beginning any treatment of the eye, test and make a record of the vision of each eye; the record might be valuable to have in case the patient should subsequently claim that the vision had been injured by treatment.

Give such constitutional treatment as may

be indicated in each individual case. Locally apply either hot or cold packs, depending on which is most comfortable and convenient for the patient for an hour at a time, three or four times a day.

An alum curd, made by stirring powdered alum into hot milk until a curd forms, may be applied night and morning in addition to, or in place of, the hot packs at that time.

If it is a simple conjunctivitis the eye may be irrigated with a solution of boric acid, or night and morning there may be instilled into each eye a drop or two of a solution containing one grain of sulphate of zinc, one-eighth grain of sulphate of morphine and one two-hundredth grain of atropine sulphate, to an ounce of distilled water. Eye salves for the various diseased conditions of the eye are put up in sterile collapsible tubes; one for conjunctivitis might be used at night in place of the drops; it would have the advantage of preventing the eye lashes from matting together during the night.

If the trouble is due, or probably due, to infection, then in place of the sulphate of zinc drops, use a 2 per cent. protargol solution; this has the advantage over silver nitrate, in that it is not painful, is better suited to acute forms,

and at the same time is effectual. The writer has always used this solution in obstetrical practice with the best results; it is not painful, it does not affect the eye like silver nitrate, and I never had a case of ophthalmia neonatorum. In all cases it is best to protect the eyes with blue or smoked glasses.

INTERSTITIAL KERATITIS is an inflamation of the cornea. It may be due to constitutional disease, but is frequently due to local injury. The symptoms are dimness of vision, constant pain, and severe photophobia; the cornea has a steamy appearance, the congested blood vessels are pink, deep seated, straight breaking into fine network, and most marked near the cornea. There may be considerable lachrymation, but little if any secretion of mucous. It will be noticed that this can be differentiated from conjunctivitis by the color and appearance of the blood vessels, the acute sensitiveness to light, the cloudy cornea, and the resulting dimness of vision. The treatment is with alteratives and tonics internally, and locally, with antiseptic irrigations, hot compresses, instillation of atropine, and bandage or protective glasses. After the acute stage has passed, gentle massage with yellow

oxide of mercury ointment, alternated with a 10 per cent. thiosinamine ointment, will help to clear up the opacity.

There are other forms of keratitis. and ulceration is quite liable to occur; but as it is intended to mention only some of the most common dieases that interfere with vision, the reader is referred to treatise on diseases of the eye for further consideration of each with treatment in detail.

IRITIS may be due to errors in refraction, to constitutional disease, extention of inflamation from other tissues, or to trauma. It frequently accompanies keratitis. The subjective symptoms are pain, photophobia, and more or less dimness of vision. Objectively the iris has a dull lusterless appearance, and the pupil is hazy and sluggish; it may be contracted, irregular and fixed. Give constitutional treatment, ever bearing in mind the frequency of syphilitic or tubercular origin. Locally, hot packs may be applied, and the instillation of a 2 per cent. solution atropine sulphate in distilled water commenced at once to dilate the pupil and prevent adhesions. Use three or four times a day until the pupil is fully dilated, then suspend until the pupil contracts a little,

then use again to full dilatation. Protect the eyes with blue or smoked glasses.

There are several forms of iritis.

CHORODITIS is an inflamation ot the vascular tunic that lies between the sclerotic coat and the retina, called the choroid. The trouble may be due to errors in refraction, to constitutional disease, to extension from other tissues, or to trauma. It usually causes dimness of vision and flickering spots, or, fantastic figures with changing forms may be seen. If any cause can be discovered direct treatment to it; otherwise give general alterative and tonic treatment. The double salt solution composed of mercury bichloride 1-50 grain and potassium iodide five grains to the dose is a good one; dissolve two grains of bichloride of mercury in about six ounces of water, and one ounce of potassium iodide in another six ounces water; when entirely dissolved, mix them, filter, and add enough water through the filter to make one pint. Give a teaspoonful three times a day after meals. Protect the eyes with colored glasses, and give rest. If there is a smarting and burning pain, instil an ointment containing one half grain holocaine and two drops adrenalin chloride to the dram.

RETINITIS is a quite frequent cause of dimness of vision, and it seldom has other subjective symptoms of disease of the eye, or objective conditions to be read by the doctor until he has made an examination for that purpose.

The inflammation of the retina may be due to extension fron an inflammation in other parts of eye, or it may be of syphilitic origin. Then again it may be due to a kidney lesion; often interstitial nephritis gives an early sign in the eye; the disturbance to vision is slight in the beginning, but gradually progresses to total blindness, if the patient lives that long. This is called albuminuric retinitis. To illustrate two extremes of the disease as they may come to the physician; a woman of about forty years of age came to me from an adjoining town, after having had an attempt to fit her eyes by several opticians without getting satisfactory results. Her vision was 20-200, and 20-50 was the best vision that could be obtained with lens; Brights disease was suspected and upon examination proved to be the case. Rest and treatment were given, but she gradually failed and died within a year.

A case at the other extreme was that of a little boy of about eleven years of age who could not see his mother standing ten feet distant,

at his first visit to me. Of course, no hope could be given for either vision or life, and he died after a few weeks. When a case comes with dimness of vision that can not be brought to near normal with correcting lens, and the cornea and iris are clear, be suspicious of, and examine for, Brights disease; its exclusion will leave you to hunt for other cause. Diabetes may also affect the eye in a similar manner to Brights. Partial detachment of the retina may occur, in which case there will be attacks of momentary blindness, and at other times flickering spots before the eyes.

OPTIC NERVE disease, either a neutritis or optic nerve atropy, will disturb the vision from slight impairment to total blindness.

CATARACT is a change in the body of the lens or its capsule. There are many varieties, and the reader is referred to some work on diseases of the eye for their consideration in detail.

Cataract is not usual to the young or in middle life; it is more common after the sixtieth year. The interference with vision depends on the location and extent of the opacity; if it is central and covers the pupilliary area only, there will be great disturbance of vision in a

bright light, but the vision will be very much improved in a semi-darkness that will induce the pupil to dilate beyond the clouded area; while if the opacity is at the periphery where it is covered with the iris in an ordinary light, it will not interfere with vision until a dim light requires a dilated pupil in order to get more light into the eye; then the cataract will be evident by its interference. A centrally located cataract is the form most frequently encountered, and when the dimness of vision can not be improved with any lens, but improves with a dilated pupil, a central cataract may be suspected; one expert with the ophthalmoscope can complete the diagnosis by objective examination. If the cataract is complete, involving the entire lens, the construction or dilation of the pupil will make but little if any difference in vision.

VITREOUS HUMOR. There are several diseases of the vitreous humor, but it is not common for opacities therein to interfere with vision to any great extent. The ophthalmoscope is the instrument with which to make diagnosis.

FIFTH PAPER.

GLAUCOMA is characterized by an increase of the contents of the eye; the lens is pressed

forward causing a shallow anterior chamber, and the intraocular tension is increased.

Oculists are not agreed on what causes this trouble.

Pain and dimness of vision are the first symptoms complained of. The disease is serious, and early diagnosis, with proper treatment, may save the patients vision.

It is important to differentiate glaucoma from conjunctivitis, iritis, and keratitis, with which it may be confounded. The following tables will aid in diagnosis; they might be arranged in one table, but since different manifestations of disease are used in each to compare with glaucoma, it is less confusing to consider each separately in comparison with it. It will be noticed that the three characteristic points found in glaucoma only are, dilated pupil, shallow anterior chamber, increased tension, and severe pain relieved by eserine.

If the symptoms are so near glaucoma that a doubt exists about its exclusion, give it the benefit of the doubt and institute treatment for it at once. Treatment for it will not harm any of the other diseases, except eserine is not the proper thing in iritis; but in that disease it will aggravate instead of relieving the pain, and thus help to clear up the diagnosis for a change in treatment.

DIFFERENTIAL DIAGNOSIS.

	Conjunctivitis.	Glaucoma.
Secretion	Hypersecretion	No secretion.
Pain	Smarting and feeling as if something might be in the eye	Neuralgic.
Pupil	Normal	Sluggish, dilated, greenish in color.
Cornea	Clear	Hazy
Tension	Normal	Increased.
Vision	Little affected	Greatly diminished.
Anterior Chamber	Normal	Shallow.

	Iritis.	Glaucoma.
Pupil	Contracted, and irregular	Dilated, and of a greenish color.
Tension	Normal	Increased.
Anterior Chamber	Normal	Shallow.
Vision	Diminished, but not suddenly	Suddenly diminished.
Atropine	Soothing	Aggravates pain.
Eserine	Aggravates pain.	Soothing.

	Keratitis.	Glaucoma.
Pain	Constant, and lancinating	Neuralgic and paroxysmal.
Pupil	Normal	Dilated, sluggish, and greenish color.
Tension	Normal	Increased.
Anterior Chamber	Normal	Shallow.

Initial treatment consists of the instillation every two to four hours of a solution of eserine, made by dissolving one grain of eserine sulphate in one ounce of distilled water. Massage the eyeball for five or ten minutes at a time, several times a day. Pure petrolatum, or an ointment containing one fourth of one per cent. eserine may be used as a lubricant for massage. If the symptoms are not soon mitigated, and the case started on the way to recovery, an expert oculist had better be consulted.

NEURASTHENIA will often affect the acuity of vision; in fact when one is nervous or very tired, their vision will often be less acute than at other times.

HYSTERIA may cause attacks of functional disturbance of vision from marked dimness to total blindness.

The treatment for both neurasthenia and hysteria is hygienic and constitutional, to build the nervous system up to normal tone.

Neurasthenia is an enervation, and hysteria is an exaggerated form of neurasthenia.

There is a lack of the elements that make up the living cell, metabolism is faulty, and the entire nervous system is exhausted. Eggs,

rolled oats, and entire wheat, or graham, are good in the line of food. Supplement the mineral matter contained in the food with salts required for the cells; such as the phosphates of calcium, potassium, sodium, magnesium, iron, and manganese. The drugs may be mixed in water in the proper proportion, to be well shaken before taken, or the syrup of hypophosphites compound, or the glycerophosphates compound, may be used instead. Give medium doses of strychnia to stimulate glandular activity. Secure free elimination by way of both bowels and kidneys. Limit work to what can be done without fatigue. Secure out of door living and deep breathing exercises. A change of scenery and climate is beneficial; a hunting and fishing trip, with a camp in the woods for a month, is an excellent change. Occupy the mind with something to replace thoughts of self. The cold sponge bath in the morning, with water containing epsom salt or common salt, followed by a brisk towel rub, may be given. A spinal ice rub given daily induces a beneficial reaction; it is given as follows: have the patient lie on the abdomen, then run a small piece of ice rapidly back and forth over the spine for about one minute; follow this with a brisk rub with a towel.

A hot bath with water containing an ounce of epsom salt to the pint of water, may be taken at bedtime.

Many cases will require a nerve sedative until the nervous system gets stronger; syrup hypophosphites compound Oz. V. and elixir valerinate ammonium Oz. III. makes a good mixture that is usually efficient; or the sedative compound tablet that is put up by nearly all pharmaceutical houses, and contains ferrous sulphate, ext. valerian, ext. sumbul, asafetida, and arsenous acid, may be given at the same time as the hypophosphites. Suggestion is also a great aid in many cases; often a formulae covering the idea that "this treatment will build up my nervous system, and I will gradually get better; I am getting better;" to repeat at the noon nap, and at bed time, until sleep ensues, urging the patient to feel that it is true while repeating it, may be given with benefit.

Electricity, if one has an efficient battery to give central galvanization, general galvanization, and general faradization, is another valuable aid in treatment.

Central galvanization is given by placing the negative electrode over the solar plexus, (a large pad should be used,) and moving the positive from vertex to coccyx.

General galvanization is given by placing the negative electrode at the feet, preferably in a basin of water, and moving the positive over the entire body.

General faradization is given by placing one pole at the feet, and going over the entire body with the other; it makes no difference which way the poles are used, as the polarity is alternating. The secondary current is best to use in nervous conditions.

A milliampere meter should be used with the galvanic current, and not more than two or three milliamperes used about the head; from five to fifteen may be used over other parts of the body, as the patient can stand with comfort. The current may be applied from ten to twenty minutes, except on the head, where not more than three minutes continuous treatment should be given.

Treatments may be given every other day, and general galvanization alternated with general faradization; central galvanization being given with each. For instance, one day give central galvanization for ten minutes, then general galvanization for ten minutes more. The next treatment give central galvanization for ten minutes, then general faradization for ten minutes.

In hysteria a modified Weir Mitchell treatment is best. The patient should be taken away from home, isolated from family and friends, and put to bed. No one but the nurse and doctor can be allowed in, or near the room. It requires a good nurse, kind and gentle, but firm, in constant attendance. Nourishment, baths, spinal ice rubs, electricity, alcohol rubs, massage, such medicine as is indicated, and lots of suggestion, with reading, story telling, conversation and games, constitute the treatment. Make up a written program daily, with food, medicine, baths, exercises, etc., so arranged that there will be something different doing every hour, when awake. Then the nurse can fill in the reading, stories and games, as is agreeable and required to keep the patient cheerful. After a few days the patient can get up, and soon be out of doors. Word can be received from, and sent to, friends, but let it be censored and nothing but encouraging messages passed. The neighbors and friends should stay entirely away from sight of the house. A great deal depends on having the right kind of a nurse, and suggestion plays an important part.

Perhaps a brief report on one of my own cases will be a help and encouragement to others.

Miss M——, aged 22, had hysterical spasms in which she would become perfectly rigid and unconscious. Treatment at home had no effect, and her parents were informed that she would have to be taken from home for successful treatment.

The upper story of a house, with only an aged man and wife below was secured, and the girl brought there and put to bed under the care of a good nurse. No one but nurse and doctor were allowed upstairs. Treatment was given as herein outlined. No spasms occurred after the first week, and within three weeks she was sent home, cured.

Many physicians have their own plan for treating these cases, and the foregoing suggestions are simply given for the benefit of those who may find anything useful therein.

Whatever the method used when the nervous system is put in normal condition, the trouble with vision will have been cured.

Disease Due to Errors in Refraction.

The second cause to bring the patient to the doctor, and in which errors in refraction may be a factor, is for disease of the lids, such as blepharitis, hordeolum, blepharospasm, and nictitation; and of the eyeball as, conjunctivi-

tis, iritis, and chorditis. When any of these troubles are persistent, or often recurring, it is well to examine the eyes for errors in refraction.

Symptoms of Defective Vision.

The third cause to bring the patient to the refractionist, is a complaint that the eyes tire and ache when at close work, or that print seems to run together and become indistinct after reading a short time. These symptoms are pathognomonic signs of defective vision. The first may be due to loss of accommodation, to muscular imbalance, or to a defective form of the eye; or each may be a factor in their combination as a cause.

The second indicates astigmatism, but is not a reliable sign that it is present. Take a record of the vision, and get busy.

SIXTH PAPER.

Reflex Symptoms.

The fourth cause for consideration of refraction by the physician may be complaint from his patient of trouble in distant parts of the body that is reflex, due to eyestrain.

Headache is the most frequent reflex symp-

tom due to eyestrain. There are many kinds of headaches, due to many different causes.

Headache may be due to local congestion, anemia, aneurism, tumor, neuritis, injury, or to adhesions as the result of some former trouble; but usually it is a reflex symptom of trouble in other parts of the body. Among those things other than eyestrain that will cause headache, are auto-toxemia due to constipation or faulty elimination by the kidneys, torpid liver, indigestion, catarrh, decayed teeth, uterine troubles, and the onset of disease.

There are many different forms of headache, both as to the character of the pain, its location, and its systemic effect. It is not within the scope of this paper to discuss headache further than in its relation to eyestrain in order to assist in diagosis as to the probability of refractive error.

Some of the various causes for headache, other than eyestrain, are mentioned that they may be considered in diagnosis by the process of elimination.

History of the case is an important factor in determining if headache is due to eyestrain. Where eyestrain is the cause, close work like reading, sewing, and writing, will bring on

or aggravate the trouble. The character of the pain is usually a dull steady ache, and its location the brow, or orbital.

The next reflex symptom of eyestrain, in frequency, is trouble with the stomach. Here, as with headache, diagnosis as to the probable cause is made by the process of elimination, and the effect that excessive use of the eyes has on the trouble. Both headache and stomach trouble may occur at the same time as reflex symptoms of eyestrain.

Again eyestrain may seriously affect the general nervous system, and through it the normal status and function of any, or many, distant organs in the body.

Diagnosis.

While eyestrain affects the system in various ways, systemic trouble may also affect the eyes, both as to vision and disease; so when a patient comes to the doctor with a complaint of eye trouble direct, or for trouble in which it is thought that eyestrain may be the cause, or a factor thereof, the first inquiry should be into the history of the case.

What are the symptoms complained of?

How long since the trouble was first noticed?

What was the previous occupation? (Note if it called for considerable eye work.)

What is present occupation? (Note its demands on the eye.)

Is the iris bright?

What serious disease has the patient had, and if any, at what time? (Systemic disease often affects the eye.)

Are the symptoms complained of aggravated by the use of the eyes, especially at close work?

Is there photophobia?

Other questions bearing on each individual case may be suggested by the patients appearance, complaint, or by answers to previous questions.

Next inspect the eyes.

Are the lids affected?

Are the conjunctiva, sclera and cornea clear?

Is the iris bright?

Do the pupils appear normal?

Is the tension of the eye balls normal?

Then consider if symptoms may come from disease of the eye that would not be visible on ordinary inspection.

After the inspection of the eye is concluded, take, and make a record of, the patients vision. Use the twenty foot distance between the patient and card of test letters, if practicable.

Six meters equal practically twenty feet, and at this distance rays of light are considered parallel as regards their practical effect in refraction; hence that is the best distance at which to take the record of vision, and when the eye is fitted with a lens at that distance, it is the lens needed for distant vision. This does not mean that a greater or less distance can not be used, providing that the letters on the test card marked for the distance used are taken as the basis for normal vision, the distance used as a numerator, and the letters read as the denominator of the fraction recording the vision.

In taking the patient's vision caution should be given not to strain the eye, but to read so far only as can be seen easily. There will be some involuntary eyestrain at the best, and the record should not be all that can possibly be seen; when the patient begins to hesitate and read incorrectly, the vision is the larger letter that was read easily and correctly.

When cycloplegia is produced in a defective eye, the vision will be found very much less, the amount of reduction depending on the kind of defect, the amount of eyestrain used in taking the first record, and the effectiveness of the cycloplegic used; hence if a patient reads

the line for normal vision, that does not prove that there may not be defective vision and the normal line read by means of straining the eye.

The defect in which the line for normal vision can be read, usually proves to be hypermetropia; place a spherical plus 0.25 lens before the eye, and if the eye is normal, or slightly myopic, the vision will be clouded; but if hyperopic, the letters will be clear and more easily read.

Next call the patient's attention to an astigmatic chart of some form; if the radiating lines are not of equal distinctness, it indicates a defect of the eye, but not necessarily astigmatism; in straining the eye it is sometimes rendered temporarily astigmatic, and when the proper spherical lens is adjusted, the lines will all be equally distinct.

Next place a white light twenty feet distant from the patient, cover one eye with the solid rubber disc, and place the chromatic lens before the other eye, so adjusted that the line of direction from the eye to the flame will pass through the thick part; if the flame appears distinctly blue, with a ring of red around it, the eye is hyperopic, and will require a spherical plus lens for its correction. If the red

ring appears broken, there is probably astigmatism present, and often the position of the part of the ring that can be seen will give an idea as to its approximate axis. If the flame appears red with a blue ring around it, the eye is myopic, and will require a minus lens for its correction; if the ring appears broken it indicates astigmatism the same as in hyperopia. Test each eye separately and note how the results compare.

From the history, inspection, and various tests, a positive and accurate diagnosis ought to be made in nearly every case as to whether there is refractive error present or not.

Mydriasis and Cycloplegia.

Providing that the eye has been found defective and a correction required, the next thing to consider is whether cycloplegia will be necessary or advisable.

There is a difference between mydriasis and cycloplegia; the former means dilatation of the pupil, while the latter means a temporary paralysis of the ciliary muscle.

Cocaine is a myriatic, but not a cycloplegic; while atropine and homatropine each produce both mydriasis and cycloplegia. One of the two

latter is generally used; each has its advantages and its disadvantages; cycloplegia from atropine is more pronounced, but its effect continues with diminishing power for several days, to the annoyance and discomfort of the patient; homatropine is sufficiently effective for practical purposes and its effect usually entirely disappears within forty-eight hours. The following is a good formula for office work:

Homatropine hydrobromate .....Gr. I

Cocaine hydrochlorate .....Gr.½

Aqua Dist. .....Dr.II

M. Sig. Instil a drop or two into each eye every ten minutes for an hour.

The case is then ready for refraction. This solution is better freshly prepared, and the quantity advisable to make at a time would depend on the volume of business done, and the probable frequency of its requirement. There is usually a little waste, and the quantity given in the foregoing prescription will be sufficient for about six cases. If one is not liable to need it six times within a week, he had better prepare only one half or one fourth of the amount at a time. One or two grains can be divided into powders of the size needed to make the desired amount, and folded in par-

affine papers. The solution is best kept in a little amber glass stoppered bottle.

Sometimes it is desirable to use atropine on account of its greater, and more prolonged effect. Often where there is a high degree of hyperopia the accommodating muscle has been accustomed to high tension, and will not readily yield to the desired amount of correction unless it is trained to the new order of things by wearing the correction while the effects of a prolonged cycloplegic is slowly fading.

Again a patient may have been given an unsatisfactory correction, or may give evidence in some way that it will be a difficult case to fit, and more profound cycloplegia is desired.

In such case the following solution may be given:

Atropine Sulphate ..... Gr. ½
Aqua Dest. .....fl.dr. 1

M. Sig. One drop in the **outside** corner of each eye three times a day.

Give a medicine dropper, and a pair of blue or smoked glasses. Show some one how to instil the drops into the eye, have them used two days, (6 times,) the colored glasses worn, and report at the office for refraction. Caution the patient about caring for the drops, on account of their poisonous nature, in a way

that will not give alarm regarding their use as directed. If it is a high degree hyperopia and the accommodating muscle will not yield to the correction as fast as the drops fade, they may be instilled once in a day or two for a while to prolong their effect.

Atropine should not be used where there is any tendency to glaucoma.

The sunlight of a bright day is painful to eyes with dilated pupils, and the refractionist ought to have two or three pair of blue or smoked glasses to loan his patients for a day or two when required.

Often the term "mydriatic" is used when it is cycloplegia as well that is intended, and is the most important of the two. This has come about naturally from the fact that atropine or homatropine is usually used, and its visible effect is mydriasis while cycloplegia is produced at the same time.

Where "drops in the eyes" are spoken of in connection with refraction, the foregoing solution, or a similar one, is meant. Occasionally a young person can be correctly fitted without producing cycloplegia; but nearly all cases under 20 years of age, a large percentage from 20 to 40, and a few between 40 and 50, will need it in order to fit them correctly. A few

lens of varying, and of opposite value, may be placed before the eye, and if the answers are prompt, positive, and logical, the case can probably be fitted without the cycloplegic; but if they are hesitating, uncertain, and illogical, it should be used at once.

Retinoscopy, or the Shadow Test.

A retinoscope is a small mirror about the size of a Lincoln U. S. one cent piece; it is mounted on a larger black disc with a small hole through its center, and attached to a handle; the silvering is removed from the mirror the size of the whole through the disc. It is used in a dark room to reflect rays of light into the patient's eye, and observe the movement of the shadow caused by slightly rotating the mirror to and fro. The character, position, and movement of this shadow varies with the different refractive conditions of the eye, and it is an objective test; hence it is valuable in diagnosis of the nature of the defect, its accuracy and value increasing with the operator's experience. An expert will make the correction with the retinoscope, and then check off the findings by use of the test letter card, and make any slight changes desired.

It is a difficult matter to use the retinoscope without dilating the pupil, and if cycloplegia is not produced the patient is liable to use the accommodation more or less, while the eye must be at rest to obtain correct results; but whenever a mydriatic is used, the refractionist should use the retinoscope for both the information and the experience gained.

There are schematic eyes, called skiascopic eyes, made by optical firms on which to practice retinoscopy; the practice is interesting and valuable.

Mirror and Movement.

There are two kinds of mirror; one with a flat surface, the other with a concave surface. It is important to know which kind you are using, also which kind is intended in any article written on the subject; for the movement of the shadow with one is just the reverse of that with the other.

At one meter distance, with a plain mirror, rays reflected from an emmetropic or hyperopic eye move with the mirror, and from an eye of more than one diopter myopia they move against it. While at the same distance, with a concave mirror, rays from an emmetropic or hyperopic eye move against the mir-

ror, and from an eye with more than one diopter myopia they move with it. Myopia of less than one diopter gives the same movement in each case as hyperopia.

Some refractionists prefer the concave, and some the plain mirror. The author of this article has both, but uses the plain one almost exclusively, and the plain one will be the one considered in these papers.

The Room and Light.

The room should be made as dark as possible; the darker the room the better the retinal illumination will appear. The light should be a very bright white light, and the chimney covered with asbestos, or other opaque substance, having a small opening opposite the flame. The light should be placed nearly on a level with the eye, and about six inches in front, and just to the left of the observer. Some place the light back of, and just above the patient's head; but the nearer the light is to the mirror the sharper will be the illumination.

Patient and Distance.

The patient should be comfortably seated, and should have the pupil dilated and the ciliary muscle put at rest with a good my-

driatic and cycloplegic; otherwise it will be very difficult to get the fundus reflex, and the accommodation is liable to be used more or less and thus render the results unreliable. Instruct the patient to look at the dark part of the disc above the mirror and not directly into it; in order not to be painful to the eye.

The best distance between observer and patient is one meter; at this distance it is easy to change the lens, and one diopter convex lens will just focus parallel rays from an emmetropic eye on the retina of the observer, so there will be no shadow movement; or if there is no shadow movement at this distance when observing the patients eye without a lens before it, there is just one diopter myopia.

Rules of Procedure.

From the foregoing facts we deduct the following rules:

When using a plain miror at one meter distance, if the shadow moves with the mirror, use a plus lens, increasing the power until the reversal point is found; (no movement.) If the shadow moves against the mirror, use a minus lens in the same way; then add a minus

one diopter to the result as a correction to get the true finding in every instance; thus:

Dark room result .....+1.00
Add .....—1.00

Correct finding 0.00
Emmetropic eye.

Again: Dark room result .....+2.50
Add .....—1.00

Correct finding .....+1.50
Hyperopia.

Again: Dark room result.....—1.00
Add .....—1.00

Correct finding .....—2.00
Myopia.

Rule for Concave Mirror.

If a concave mirror should be used, the movement of the shadow would be just the reverse from what the same rays from the same eye on a plain mirror would be, and a plus lens would have to be used when the shadow moves against the mirror, and a minus lens when it moves with the mirror, to find the point of reversal; but the correction can be made by adding a minus one diopter to the dark room result in each instance the same as

is done when a flat mirror is used. Or some prefer to subtract a plus one diopter. The result will be just the same, and it is optional with the operator which way to do.

Astigmatic Shadow.

If the eye is astigmatic the edge of the shadow may appear straight instead of crescentic, as in a spherical defect; and if the axis is not in the vertical or horizontal meridian, the shadow may move obliquely across the mirror and on a line with the eye, tilt the mirror at an angle parallel with the shadow, and find the reversal point; then repeat the operation at right angles to the first; add the minus one diopter to each to get the correct finding, and the difference in results will be the amount of astigmatism; the kind depending on the kind of lens used to find the reversal point.

False Shadows.

If trouble is experienced in throwing the reflected rays into the patient's eye, hold the hand or other object a little in front of the mirror and on a line with the eye, tilt the mirror until the light showing on the hand is in line with the eye, then remove the hand.

When the mirror is rotated too much a shadow movement will appear on the face or cornea, and care must be taken not to confuse this with the shadow from the fundus of the eye. The fundus reflex is seen as a red glare, and the mirror can be rotated but very little without losing it.

Hypothetical Cases.

No. 1. A crescent edge shadow is seen, its movement with the mirror. We try a +1.00 lens; the movement is still with the mirror; we next try a +1.50 lens; no movement; add for correction, —1.00; we have, +0.50 hyperopia.

No. 2. Crescent edge shadow, movement against the mirror. We try a —1.00 lens and get movement with the mirror; this shows over correction, and we try —0.75 lens and find no movement; add correction, —1.00 we have —1.75 myopia.

No. 3. A straight edge shadow, moves with the mirror, and the movement is faster in one meridian than in the meridian at right angles to it; this indicates astigmatism; we try a +1.00 lens; this stops the movement in one meridian, but there is still movement with the

mirror in the other; we now try a +1.50 lens in this other meridian only, and find that it stops movement in that. We then add —1.00 to each to correct for one meter distance and we have:

+1.00
—1.00

0.00 Normal in the first meridian.
+1.50
—1.00

+0.50 Hyperopia in the second meridian.

This gives +0.50 astigmatism, and the axis of the cylinder will be at right angles to the meridian that requires the stronger correcting lens.

It is not always easy to catch the shadow movement distinctly, and to get the reversal point. But one can usually get an idea of the kind of defect, and with more and more experience the operator will become more and more proficient.

Abundant practice on a skiascopic eye will be a great help to the beginner in retinoscopy.

The foregoing are facts for practical use; the reason why, may be found in the laws of optics governing reflected light, and can be read up in works on that subject.

The shadow test in detail can be found in some good work on retinoscopy.

SEVENTH PAPER.

In considering how best to present the technique of refraction in a way to be most helpful to the beginner, the conclusion is, that cases representing different phases of the work taken from my record book, and a process of fitting given, will be of most service. This will give a good idea of one way to proceed, and will bring out many important points; other methods of procedure will come to the operator through practice. It must be remembered that practice is necessary to proficiency.

Hypermetropia.

As stated and shown by illustration in the third paper, March issue, hypermetropia, also called hyperopia, is a condition where the antero-posterior diamter of the eye is too short in proportion to the power of its refractive media; hence parallel rays of light, such as come from distant objects, focus beyond the retina. This requires constant use of the accommodation for distant vision, and excessive use for near work, which results in tiring the eyes and giving the symptoms of eyestrain. Often by the time a diagnosis of the true condi-

tion is made, the correction will be nearly completed.

Case 1. Miss Ethel ——, age 18. Headache, eyes ache, print runs together when reading; L. E. V. 20-40, R. E. V. 20-40.

We cover one eye with the solid disc and test the other. Lines on astigmatic chart appear of equal distinctness. With the chromatic lens the flame appears blue with a red ring surrounding it.

We place the stenopaic slit and revolve it slowly to include every meridian; vision is the same at all points. This seems to be a clear case of hypermetropia, and we remove the stenopaic slit and place a spherical + 0.38 lens in the trial frame, and vision is improved; we then hold in front of this a +0.25, and vision is further improved. We change the + 0.38 in the frames to + 0.75, and again try the 0.25 over it, which further improves vision; we then change to + 1.00 in the frames and again try the 0.25 over it, and vision is now improved to 20-20. We change to + 1.25 and again try the 0.25 over it, and find that it clouds the vision, thus showing that a + 1.25 is all that will be accepted. We then cover the eye tested and proceed with the other eye in the same manner, with precisely the same

results; this shows hyperopia of 1.25 in each eye, and our prescription will read:

L. E. Spher. + 1.25.
R.E. Spher. + 1.25.

The answers have been prompt and positive; hence this young person has been fitted without drops, and the plus 1.25 spherical lens prescribed two years ago, relieved the symptoms and has given perfect satisfaction.

Some prefer to place a strong plus lens that will blur the vision in the frame, and then try minus lens of increasing power over it until enough is neutralized to make vision clear; the amount left unneutralized will be the correction.

Case 2. Mrs. H———, age 42. Headache, stomach trouble. L. E. V. 20-40. R. E. V. 20-40.

Answers to various tests are hesitating and doubtful, so the homatropine solution given in a previous paper is used. Vision under the mydriatic is 20-80 each eye, thus showing considerable eyestrain.

Retinoscope shows, L. E. Spher.....+3.00
Add for correction .....—1.00

Hyperopia .....+2.00

Retinoscope shows, R. S. Spher.....+2.50
Add for correction .....—1.00

Hyperopia .....+1.50

We then use the test letter card in the same manner as in case 1, and find that the full correction indicated by the retinoscope will not be accepted; but that a + 1.25 each eye gives vision 20-20. When the effect of the drops is gone a person will not accept the full correction made under them, and an allowance of from 0.50 to 1.00 has to be made for the action of the accommodating muscle, and deducted from the correction recorded, when writing the prescription. If convenient to see the patient after 48 hours, it is best to do so and find just how near the correction will be accepted. In this case + 0.50 was allowed and the prescription written for + 0.75 each eye. This relieved the symptoms of eye-strain.

We note two points in this case. 1st. That although 42 years of age, a cycloplegic was necessary. 2nd. That the ciliary muscle was not put completely at rest, and she would not accept the full correction indicated by the retinoscope, so the minimum allowance for drops was deducted when writing the prescription. Had the ciliary muscle been completely at rest, she would have accepted the full retinoscope correction when using the test letter card, and probably a deduction of 1.00 would have been

required in writing the prescription to have made the glasses comfortable and satisfactory.

Case 3. Miss Laura M———, age 18. Headache, eyes ache, print runs together when reading. L. E. V. 20-80. R. E. V. 20-80.

Radiating lines in astigmatic chart are not equally distinct, thus indicating astigmatism. We cover the right eye and use the chromatic test with the left. The flame appears blue with a red ring surrounding it. We then use the stenopaic slit, and find vision the same in every meridian. We then set the slit in the horizontal meridian and try a + 0.25 lens which improves vision; over this we hold a + 0.25 with further improvement; we then change to a + 0.50 in the frame, and again try the 0.25 over it with still further improvement; a +0.75 is now placed in the frame and the 0.25 again tried; it slightly blurs vision and shows that 0.75 is sufficient correction. We now turn the slit into the perpendicular meridian and proceed to test in the same way with precisely the same result; this indicates a spherical correction, and we remove the stenopaic slit and place a + 0.75 spherical lens in the frame; this gives normal vision, and the lines in the astigmatic chart are equally distinct. We next

test the right eye in the same manner with the same result, and our prescription will read:

L. E. Spher. + 0.75.

R. E. Spher. + 0.75.

The glasses relieved all symptoms and gave satisfaction. The answers were prompt and positive, and drops were not used, although the girl was only 18 years of age.

Note in this case that the lines in the astigmatic chart did not appear equally distinct with the uncorrected eye, thus indicating astigmatism; but other tests indicated a spherical defect, and when the spherical correction was made the lines in the astigmatic chart were all equally distinct. This shows that the apparent astigmatism was temporarily produced by straining the eye, and that the chart alone cannot be relied upon to either diagnose or correct astigmatism; but that it must be used simply as an aid in conjunction with other tests.

Myopia.

In this condition the antero-posterior diameter of the eye is too long in proportion to the power of its refractive media, and parallel rays of light focus before reaching the retina; a concave lens of sufficient power to disperse the rays enough to focus at the desired point is required.

Case 4. Miss Cora M———, age 19. Defective vision, headaches. L. E. V. 20-80. R. E. V. 20-160.

L. E. No difference in lines in astigmatic chart. With chromatic test the flame appears red with a blue ring surrounding it.

With the stenopaic slit no meridian can be found where vision is either better or worse. This is evidently a case of myopia requiring a spherical correction, and we remove the stenopaic slit and insert a — 0.38 lens; vision is slightly improved, and over this we hold a — 0.25 lens with further improvement; we then change to — 0.75 in the trial frame and again try the 0.25 over it, which gives vision 20-20. We then have the patient look at a large letter at the top of the card through the 0.75 lens that is in the frame, and note if the letter looks any smaller when the 0.25 is placed over it; it does not, so the two combined, making — 1.00 is considered the proper correction.

R. E. No difference in lines on astigmatic chart. With chromatic test the flame appears red with a blue ring surrounding it.

The stenopaic slit is placed and revolved slowly; no meridian is found where vision is changed. The slit is removed, and considering the vision and tests of the two eyes, and the

correction taken by the left eye, a —0.75 is taken as the first lens tried; this improves vision very much; we next hold over this a — 0.25; there is further improvement, and we change to — 1.00 in the trial frame, and again try the 0.25 over it; this brings the vision to 20-20; we then have the patient look at large letters through the 1.00 and note if they appear smaller when the 0.25 is placed over it; they do not, so the two combined, making — 1.25 is considered the correction for the right eye, and our prescription will read:

L. E. Spher. — 1.00.

R. E. Spher. — 1.25.

This gave good vision and relieved the symptoms of eyestrain. Notice in this case that as we came near the final correcting lens we had the patient look at a large letter and note if it looked smaller when an additional — 0.25 was placed over it. In correcting myopia one has to be very careful or the patient will accept too strong a lens; the over correcting lens will slightly diminish the size of a distant object, and the foregoing method is one very good way of guarding it.

Astigmatism.

Case 5. Freeman W———, age 11. Defec-

tive vision, eyes ache when reading or at study. L. E. V. 20-40. R. E. V. 20-40.

L. E. Lines in astigmatic chart, meridian 150 are most distinct. With chromatic test the flame appears blue with a broken ring of red outside. We place the stenopaic slit and revolve it slowly; normal vision is found in meridian 140, and at right angles to this, viz. 50, we find poorest vision; we try a + 0.25 lens over the slit and it improves vision; this is placed in the trial frame behind the slit and a second 0.25 held over it; this does not improve it further, and we try a 0.38 on place of the 0.25; this gives normal vision in this meridian, thus showing hyperopic astigmatism 0.38, and the axis of the cylinder will be at right angles with the meridian requiring the higher correcting lens; viz., 140. We now turn the cross on the clock dial to 140, remove the disc and lens from the trial frame, and insert a cylinder + 0.38 with the axis near 50, tell the patient to watch the letters and say when vision is all right, and slowly revolve the axis toward 140; as it nears this axis the patient says it is good; we note the axis, then turn it to 140, and find vision still better, and 20-20. The lines in the cross are also equally distinct; this checks off and proves the previous findings. We next test

the right eye. The lines on astigmatic chart in meridian 30 are most distinct. The chromatic test gives a blue flame with a broken red ring around it. We place the stenopaic slit, and since the combined axis in symmetric astigmatism is 180, and the left eye was found to be 140, we try the slit at 40 and find normal vision. We then turn it at right angles in this meridian, viz., 130, and find vision to be poorest. We try a + 0.25 lens, and it gives normal vision. We then try 0.38 in place of the 0.25 and find that 0.25 gives clearest vision. We now turn the cross to 40, remove the disk and lens, and place a + 0.25 cylinder with axis near 130, and direct the patient to say when the best point is found as we revolve it toward 40; he gives the word at 40, and we find that turning it either way from that meridian diminishes acuity of vision. The lines in the astigmatic chart are equally distinct. Thus we check off and prove previous findings and have simple hyperopic astigmatism 0.25 axis 40 for this eye. We now have both eyes fitted and the prescription will read:

L. E. Cyl. + 0.38. Ax. 140.

R. E. Cyl. + 0.25. Ax. 40.

The answers were prompt and positive, and this boy eleven years of age was fitted without

drops. His symptoms were relieved, and he has worn his glasses over two years with satisfaction.

Case 6. Mrs. P———, age 39. Defective vision, headaches. L. E. V. 20-60. R. E. V. 20-30.

This woman had been previously fitted without drops, and the glasses did not prove satisfactory, so we now use the mydriatic. Under the mydriatic, L. E. V. 20-110. R. E. V. 20-110.

L. E. Lines in astigmatic chart in meridian 120 are most distinct. Chromatic test, flame appears blue with partial red ring.

We place the stenopaic disk and revolve it slowly; meridian 120 gives the best vision. We place over a + 0.25 lens and vision is slightly improved; we then try a + 1.00 and it is very much improved; this we slip into the trial frame and try the 0.25 over it with further improvement; we then change to 1.25 in the frame and again try the 0.25; this brings vision to 20-20, and we change to the sum of the combined lens, 1.50 in the trial frame. We now turn the slit at right angles to this meridian, viz., 30, leaving the 1.50 lens in place, and try the + 0.25 over it with some improvement; we change to 1.75 in the frame and try the 0.25 over it again with further improvement; then

change to 2.00 and try the 0.25 again; this brings vision to 20-20, making 2.25 required in this meridian. The difference between 1.50 required in the 120 meridian, and 2.25 reqiured in the 30 meridian shows the amount of astigmatism to be 0.75. The axis of a cylinder must be placed at right angles to the meridian requiring the stronger lens, so we have for this eye, a compound lens as follows: Spher. + 1.50, Cyl + 0.75 Axis 120. We place this combination in the frame, turn the cross to 120, and find vision 20-20 and the lines of the cross equally distinct.

We now test the right eye. Lines in astig matic chart meridian 180 are most distinct. With chromatic test the flame appears blue with a broken red ring around it. We place the stenopaic slit, revolve it slowly, and find the best vision in meridian 180. Considering the correction that the left eye required we place a + 1.00 lens as the first trial; vision is very much improved, and we hold over it a + 0.25 with further improvement; we change the lens in frame to 1.25 and again try 0.25 over it; this gives vision 20-20, and we change to 1.50 in the frame. We now turn the slit at right angles to this meridian, viz., 90, leaving

the 1.50 lens in place, and try over it a + 0.50; vision is improved and we change to + 2.00 in the frame and try 0.25 over it; this gives 20-20 vision and makes the correction in this meridian 2.25. The difference between 1.50 and 2.25 shows 0.75 astigmatism in this eye, and the axis will be at right angles to 90, the meridian requiring the stronger lens, viz., 180; making the correction of this eye, Spher. + 1.50, Cyl. + 0.75, Ax. 180. We place this combination in the trial frame, turn the cross to 180, and find vision 20-20, and the lines on the astigmatic cross all alike.

Each eye may be checked up after using the stenopaic slit, by removing the slit and placing in the frame a spherical and a cylinder, each 0.25 or 0.50 lower power than recorded with the slit, then holding over them a spherical 0.25 then a cylinder 0.25, and let the patient choose which gives best vision; then change the power of the lens chosen, in the frame, and continue in that way until 20-20 vision results. Sometimes a quarter dioptre will thus be changed from the spherical to the cylinder, or from the cylinder to the spherical.

As previously stated when the accommodating muscle is put at rest with drops, the pation will require a deduction of from 0.50 to

1.00 in the spherical part of the prescription from the full correction made under the mydriatic. The cylinder correcting the astigmatism is never changed. In this case a deduction of 1.00 was made, and the prescription written:

L. E. Spher. + 0.50, Cyl. + 0.75, Ax. 120.
R. E. Spher. + 0.50, Cyl. + 0.75, Ax. 180.

This case is one of compound hyperopic astigmatism.

This case is selected to show: 1st. That though nearly 40 years of age, a cycloplegic was necessary in order to correctly fit her; the lens accepted without drops were not right or satisfactory; but the foregoing correction made under a mydriatic relieved the symptoms of eyestrain, and she has worn her glasses with comfort for the past three years.

2nd. It will be noticed that the astigmatism in the right eye is against the rule; it is hyperopic at an axis of 180, instead of myopic.

3rd. That the astigmatism is unsymmetric; in that the combined axes of the two eyes do not make just 180 degrees, as it would if symmetric. This form is not common, and is quite troublesome.

There is another form of astigmatism occasionally found that might be called symmetric,

in which the combined axes of the two eyes do not make just 180 degrees, but in which they are each in the same meridian, and thus parallel.

In order to give an idea of the usual proportion of the various forms of astigmatism as regards axis, one hundred cases have been taken from my record book as they run, with the following result.

Symmetric, combined axes making 180 degrees	86
Symmetric, parallel, axes same in both eyes	3
Unsymmetric, combined axes more or less than 180 degrees	11
	100

It will be remembered that astigmatism with the rule is so called when, if hyperopic, the axis is at or near 90 degrees, and if myopic, the axis is at or near 180 degrees. And astigmatism against the rule is where conditions are the reverse of the foregoing. One hundred cases of astigmatism taken from my record book as they run, show:

Astigmatism with the rule	76
Astigmatism against the rule	18
Indifferent, the axis being between 35 and 55 or 125 and 145	6
	100

Case 7. Miss W———, age 20. Headaches, and nervous. L. E. V. 20-40. R. E. V. 20-40.

L. E. Lines in astigmatic chart in meridian 180 are most distinct. With chromatic test the flame appears pink with a broken circle of blue outside. We place stenopaic disk and revolve it slowly; in meridian 165 vision is best and nearly normal; we turn the slit at right angles, viz., 75, and try a — 0.25 lens; vision is improved. For a check, or proof, we try a + 0.25, and vision is clouded. We slip the — 0.25 in the trial frame and try a second — 0.25 over it; this brings vision to 20-20. We remove the stenopaic disk and lens, turn the cross to 165, place a — 0.50 cylinder in the frame at axis about 75, and slowly revolve it toward the 165 meridian, telling the patient to say when it reaches the point of best vision. She gives the word at 165; we try it at 180; but find 165 the best. Vision is 20-20, and the lines in the astigmatic cross are alike.

R. E. Astigmatic lines meridian 180 are most distinct. Chromaic test, the flame appears pink with a broken blue ring around it.

We place the stenopaic disk, and remembering that most cases of astigmatism are symmetric, we try the slit in meridian 15, and find normal vision; we then turn it at right angles,

viz., 105, and place over it a — 0.25 lens; vision is improved; we slip this into the frame and try another —0.25 over it; this brings vision to 20-20. We then remove the lens and stenopaic disk, and insert a — 0.50 cylinder at axis about 105 and turn it slowly toward 15; patient gives the word for good vision near 15; we turn it to 15 and find vision 20-20. We then turn the astigmatic cross to meridian 15, and the lines in both directions appear alike. Each eye has simple myopic astigmatism.

The prescription will read:

L. E. Cyl. — 0.50, Axis 165.

R. E. Cyl. — 0.50, Axis 15.

This case really ought to have had a cycloplegic, and the fitting was given with the understanding that if not satisfactory she should come for refitting under a mydriatic. Symptoms were relieved, and glasses were satisfactory. The more experience one has in fitting, the more cases he can fit without drops, and better he can judge what cases it will do to fit without them. It would be better to use drops in nearly all cases under fifty years of age; but sometimes on account of time, and sometimes on account of the patients wishes, it is desirable to make the corrections without the use of drops, if it can be properly done.

EIGHTH PAPER.

Case 8. Mr. H——, age 37. Eyes smart and ache, specks float before them, and stomach trouble.

L. E. V. 20-50. R. E. V. 20-50. We test the left eye; lines on astigmatic chart in meridian 150 are most distinct. With chromatic test the flame appears red with broken blue ring around it. We place the stenopaic disk in the trial frame and revolve it slowly; best vision is found in meridian 150, but it is not normal; we slip a —0.25 lens into the trial frame behind the disk; it improves vision, and we try a —0.25 over it which brings vision to 20-20. We change to —0.50 in trial frame and turn the slit at right angles, viz. 60, and try the —0.25 over it; this gives vision 20-20, thus requiring —0.75 in this meridian. The difference between 0.50 in meridian 150 and 0.75 in meridian 60 gives —0.25 astigmatism with axis 150; we remove the stenopaic disk and lens, and place the combination Spher. —0.50 Cyl. —0.25 Ax. 150 in the trial frame, turn the cross on the clock dial to axis 150 and find vision normal, and the lines in astigmatic cross equally distinct. We next test the right eye. The best lines in the astigmatic chart are in

meridian 30. With chromatic lens the flame appears red with a broken ring of blue around it. We place the stenopaic slit and revolve it slowly, and find best vision in meridian 30, but not normal; we slip a —0.25 into frame and vision is 20-20; we revolve slit at right angles, viz. 120, leaving the 0.25 lens in place, and try a 0.25 over it; this gives vision 20-20 and makes the correction —0.50 in this meridian; the difference between this and the 0.25 correction in meridian 30, is 0.25, the amount of astigmatism with the axis at 30. We remove the stenopaic slit, and place the full correction in the frame, Spher. —0.25 Cyl. 0.25 Ax. 30, turn the astigmatic cross to meridian 30, and find vision normal and the lines in the cross equally distinct.

Our prescription will now read:

L. E. Spher. —0.50 Cyl. —0.25 Axis 150.

R. E. Spher. —0.25 Cyl. —0.25 Axis 30.

This is a case of compound myopic astigmatism.

Local and hygienic treatment was given in addition to glasses.

Case 9. Miss M———, age 45. Defective vision, eyes ache, headache, print runs together. L. E. V. 20-80. R. E. V. 20-40.

Distant Vision.

L. E. Astigmatic chart, lines in meridian 150 are most distinct. Chromatic test, flame appears red with broken blue ring outside. We place the stenopaic slit and revolve it slowly; best vision is found in meridian 150, but it is not normal. We slip a —0.25 lens into the frame with improvement; over this we hold a second —0.25 which brings vision to 20-20. We now change the lens in the frame to —0.50 and turn the slit at right angles, viz. 60, and try the 0.25 lens over it; vision is improved and we change to —0.75 in the frame and again try the 0.25; this brings vision 20-20, and makes the correction —1.00 in this meridian. The difference between 1.00 in meridian 60 and 0.50 in meridian 150 is 0.50, the amount of astigmatism, and the axis must be at right angles with the meridian requiring the stronger correcting lens, viz. at 150; then we have as correction for this eye, Spher. —0.50 Cyl. —0.50 Ax. 150. Remove the disk and lens, and place the combination in the frame, turn the cross to axis 150, and we find vision normal and the lines in the cross all alike. We now correct the right eye. The lines in astigmatic chart meridian 180 are best. With chromatic test

the flame appears red with broken blue ring around it. We place the stenopaic slit and revolve it slowly; the best vision is in meridian 180, but it not normal; we slip in a —0.25 lens and vision is 20-20, we now turn the slit at right angles, viz. 90, and try a —0.25 over it; vision is improved and we change to —0.50 in the frame and again try the 0.25; this does not improve it and we try —0.12; this brings vision 20-20, and makes the correction —0.62 in this meridian; the difference between 0.62 in meridian 90, and 0.25 in meridian 180, gives the amount of astigmatism —0.37 axis 180. Optical companies do not usually grind 0.37, but 0.38; so the correction for this eye will be, Spher. —0.25 Cyl. —0.38 Ax. 180. Remove disk and lens, place the combination in frame, turn the astigmatic cross to meridian 180, and we find vision normal, and the lines in the cross alike.

This corrects the eyes for distant vision, but this woman has lost her accommodation to an extent that an additional correction is required for reading and near work.

To correct for loss of accommodation always requires a spherical convex lens over the correction for distant vision. This does not mean that the reading lens will always be convex;

for instance, supposing that a patient has myopia requiring —2.00 for distance, and the loss of power for accommodation is equal to one diopter; then +1.00 over —2.00 for distance, would leave —1.00 for reading. Or if the distant vision required —1.00 with the same loss of accommodation, then +1.00 over —1.00 for distance would leave the eye just right for reading without any glasses. Again, if the distant vision requires —0.50, and the loss of accommodation is the same, then +1.00 over —0.50 for distance would leave +0.50 for reading; and if normal for distance it would require just the +1.00 for reading, and if distance requires +1.00, then +2.00 would be required for reading. Thus it will be seen that after the correction for distance is made, the correction for loss of accommodation is simply adding a plus spherical of sufficient power to focus at the near point desired. If a reading glass only is wanted, the distant vision should be tested first in order to find if there is astigmatism present.

We have the correction for distance in this case, and now take the little card of test type for reading distance, and test each eye separately. The astigmatic lens must always be left the same as for distance. We try a +0.50

spherical over the left eye to just neutralize the —0.50 spherical part of the correction for distance, and find that it will require more than neutralizing for the reading distance; so for convenience we remove the —0.50 spherical lens for distance and slip in the +0.50; there is some improvement, but the lines read indicate as much more required, and we change to +1.00; this brings focus nearly right, and we change to +1.25 which brings focus right and No. 60 type can be easily read; then we have for reading with the left eye, Spher. +1.25 Cyl. —0.50 Ax. 150.

We next test the right eye in the same manner and find that it also takes a +1.25 spherical for it, with the cylinder for distance. Our full prescription will now read:

For Distance.

L. E. Spher. —0.50 Cyl. —0.50 Ax. 150.
R. E. Spher. —0.25 Cyl. —0.38 Ax. 180.

For Reading.

L. E. Spher. +1.25 Cyl. —0.50 Ax. 150.
R. E. Spher. +1.25 Cyl. —0.38 Ax. 180.

Had we left the spherical in for distance when testing for reading it would have taken a spher. +1.75 over the left eye, and +1.50 over the right eye; and adding them together

to write the prescription for reading, we would have +1.25 for each eye as written. If cement bifocal glasses are to be ordered, a wafer of sufficient power to make the proper correction for reading will be cemented over the lower segment of the lens as required for distant vision, and the prescription for the reading part would be best written as in the foregoing; but if the glasses for reading are to be separate, the part for reading can be transposed to make a more simple combination, by writing for a plus cylinder of the same power as the minus one, with the axis at right angles to it, and deducting the same power as the cylinder, from the spherical; thus: L. E. Spher., +0.75 Cyl. +0.50 Axis 60. This is a simpler lens, and analysis will show them both to give the same result.

In the Spher. +1.25 Cyl. —0.50 Axis 150, we have +1.25 in the 150 meridian, and 1.25 less 0.50 equals +0.75 in the 60 meridian; after transposing we have +0.75 in the 60 meridian, and 0.75 plus 0.50 equals +1.25 in the 150 meridian. In the former we use the full power of the spherical and deduct from it with a minus cylinder axis 150, enough to get the required amount in the 60 meridian. In the latter we use the spherical for the amount required in the 60

meridian and add enough to it with a plus cylinder, axis 60, to make the required amount on the 150 meridian. The result is the same, and as previously stated, the former is best when cement bifocals are to be ordered, because the minus cylinder ground for distant vision is used and a wafer of sufficient power to make the reading part cemented over it, but the latter form is best when the glasses are to be ground for reading only, because it is a more simple lens. To prove that any transposed formula is the same as the original in effect, put the original combination in one eye of the trial frame, and the transposed combination in the remaining eye; then the same neutralizing combination should neutralize both of them. (How to neutralize will be given in another place.) When transposing, if there is any doubt about the result, always neutralize them both with the same combination.

In this case the prescription is written as per the foregoing for cement bifocals; but had separate reading glasses been ordered the prescription would have been written as follows:

For Distance.

L. E. Spher. —0.50 Cyl. —0.50 Axis 150.
R. E. Spher. —0.25 Cyl. —0.38 Axis 180.

For Reading.

L. E. Spher. +0.75 Cyl. +0.50 Axis 60.

R. E. Spher. +0.87 Cyl. +0.38 Axis 90.

The foregoing correction relieved all symptoms and gave normal vision with this patient, and she has now worn her glasses several years with pleasure and comfort.

It will be noticed that the astigmatism in this case is unsymmetric; but the case is selected to show how to correct a case of compound myopic astigmatism, with presbyopia, and how to write the prescription if to be ordered cement bifocals, and how to transpose and write it if to be separate glasses for reading. There are several kinds of bifocals, some with the reading part ground independent from that for distant vision, and some with the reading part combined with the lens for distance. Each has its advantages and its disadvantages; transposing the reading part would be done in writing a prescription for any of the former kind, but with none of the latter.

Case 10. Mrs. M———, age 46. Defective vision, headache.

L. E. V. 20-100. R. E. V. 20-110.

This is a case of mixed astigmatism. The appearance of the lines in astigmatic chart, and of the flame with the chromatic test, in

such defect, depends very much on whether the plus or minus factor predominates, and to what degree. In this case neither one was recorded.

L. E. with stenopaic slit slowly revolved meridian 180 gives best vision. We slip a +0.25 lens into trial frame, and vision is improved to about normal; we try a second 0.25 over it which slightly clouds vision. We now turn the slit to axis 90 and hold the 0.25 over it; vision is made worse; we then change the +0.25 in the frame to —0.25 which slightly improves vision; considering the probable correction needed we try —1.00 over this with great improvement; we change to —1.25 in the frame and try the 0.25 over it with further improvement; we change to 1.50 in the frame and again try the 0.25 over it which brings vision to about normal; we now have the patient look at a large letter through the 1.50 and note if it looks any smaller when the 0.25 is held over it; it does not, and their combined value 1.75 is the correction in this meridian.

Where we have mixed astigmatism instead of using crossed cylinders we use a spherical for the lesser degree of correction, and a cylinder of the opposite kind at the proper axis for the greater degree. This makes a simpler

lens to grind. But in making the combination we must remember that the spherical neutralizes the amount of its power in the cylinder and the cylinder must be written just that much more than the correction wanted in that meridian. In this case the 180 meridian requires the least correction and a +0.25 spherical corrects it; the 90 meridian requires —1.75 correction, and we want to leave the +0.25 in meridian 180; so we will use a minus cylinder with axis at 180; but the plus spherical will neutralize 0.25 of the cylinder in meridian 90, so in order to get —1.75 we will have to use a —2.00 cylinder; then our correction for this eye will be, Spher. +0.25 Cyl. —2.00 Axis 180. This combination placed in the trial frame gives normal vision.

We next test the right eye. The stenopaic slit gives best vision in meridian 180; we slip in a +0.25 lens; improved; over this hold a +0.25; this brings vision normal, and makes the correction in this meridian +0.50. We now turn slit at right angles, meridian 90, and, considering the correction required by the left eye, try —1.00 with improvement; over this we hold —0.25; more improvement and we change to 1.25 in the trial frame and again hold the 0.25 over it; this brings vision to nor-

mal, and we have patient look at a large letter through the 1.25 and note if it looks smaller when the 0.25 is held over it; it does not, and the combined value of the two, —1.50, is the correction for this meridian. We now remove the disk and lens, and make the combination in the frame. The 180 meridian takes the lowest power lens and we correct it with a spherical +0.50. Meridian 90 requires —1.50 correction, and since the plus spherical will neutralize 0.50 of the cylinder, we will use a cylinder —2.00 axis 180, and our combination will be Spher. +0.50 Cyl. —2.00 Ax. 180. The full prescription will read:

L. E. Spher. +0.25 Cyl. —2.00 Ax. 180.
R. E. Spher. +0.50 Cyl. —2.00 Ax. 180.

This correction relieved the symptoms and gave satisfaction to this patient.

Mixed astigmatism is the most difficult to correct, and we will give another case to further illustrate how to use and combine the spherical and cylinder.

Case 11. Miss Glenna, age 12. L. E. V. 20-80. R. E. V. 20-200.

Under mydriatic, L. E. V. 20-110 R. E. V. fingers. No record of retinoscope, astigmatic chart, or chromatic lens. L. E. The stenopaic slit slowly revolved gives best vision in mer-

idian 180. We slip a +0.25 lens into frame and it improves vision; we hold over this a second +0.25, which brings vision nearly normal; we change to 0.50 in the frame and again try the 0.25 over it; this clouds vision, and +0.50 is taken as the correction for this meridian. We now turn the slit at right angles, meridian 90, and find that a plus lens makes vision worse; we remove the plus lens, and knowing that a strong correction will be required place a —1.50 in the frame for the first trial; this improves vision considerable, but lacks so much of normal that we change to —2.25; this greatly improves it, and we hold over it a —0.25 with further improvement; we change to 2.50 in the frame and again try the 0.25 over it; this brings vision to normal, and we have patient look at a large letter through the 2.50 and note if it looks smaller when the 0.25 is held over it; it does not, and their combined value, —2.75, is the correction for meri dian 90.

We remove the disk and lens, and make the required combination in the trial frame. The lesser correction is in meridian 180 and we use a spherical +0.50 for it. Meridian 90 requires —2.75 and the plus spherical will neutralize 0.50 of the cylinder, so we will add that

much to it and use a cylinder —3.25 axis 180; this gives the required correction in each meridian, and normal vision.

We now test the right eye. The stenopaic slit gives best vision in meridian 180. We slip a +0.25 lens into the frame; it slightly improves vision, but a strong correction is indicated, and we hold over it +1.00, this is great improvement, and we change to +1.25 in the frame and try 0.25 over it which makes it still better; we change to 1.50 and again try the 0.25 over it; this gives normal vision and makes +1.75 the correction in meridian 180. We now remove the lens, turn the slit at right angles, meridian 90, and considering the vision, and the correction that the left eye required, we place a —3.00 in the frame at the first trial; this improves vision very much, but lacks considerable of normal, and we change it to a —3.50 with further improvement; over this we hold a —0.25 which is still better, and we change to 3.75 and again try the 0.25 over it; this brings vision about normal, and we have patient look at a large letter through the 3.75 and note if it looks any smaller when the 0.25 is held over it; it does not, and the value of the two,—4.00 is the correction for meridian 90. We now remove disk and lens

and make the combination in the frame. Meridian 180 takes the lesser power lens, and we correct it with a spherical +1.75. Meridian 90 requires —4.00 correction, and since the spherical will neutralize 1.75 of the cylinder, we will add that much to the correction required and use a cylinder —5.75 axis 180. This corrects meridian 90, and we have Spher. +1.75 Cyl. —5.75 Ax. 180, which gives normal vision for this eye. Our prescription will now read:

L. E. Spher. +0.50 Cyl. —3.25 Axis 180.

R. E. Spher. +1.75 Cyl. —5.75 Axis 180.

These were very defective eyes for a girl of 12, but the correction enabled her to stand as usual at the piano with others and read the music and words to sing.

In combining a spherical and a cylinder of opposite values, always remember that the spherical neutralizes just the amount of its power from the cylinder in the meridian at right angles to the axis of the cylinder, and gives just the full value of the spherical in the axis of the cylinder.

Presbyopia.

This condition, also called loss of accommodation, is due to loss of power in the ciliary

muscle, and to loss of elasticity in the lens, whereby the lens fail to assume a sufficiently convex form to focus at the reading point. A reading lens is usually first required at about fifty years of age, and with advancing years the lens will occasionally need changing for stronger ones. With a slight amount of myopia present, the necessity for a reading lens may be delayed. The loss of accommodation may be hastened by disease, environment, occupation, neglect or abuse of the eyes, or other condition special with the individual, and sometimes it occurs quite early in life.

Case 12. Dr. H———, age 53. Vision defective at reading distance.

L. E. V. 20-20. R. E. V. 20-20.

There are no reflex symptoms of eyestrain, and distant vision appears normal, so we diagnose this as a case of presbyopia, and proceed to fit lens for the reading distance.

We cover the right eye with the solid disk, and hold the small card of test letters for reading distance about 14 inches from the eye and find how small type the patient can read easily; this gives an idea of the strength lens that will be required, and we slip a +0.75 into the frame; this improves vision, but the finest type (No. 60, equal to threading a nee-

dle), is not easily read; we have him look at type about newspaper size and slowly move the card back and forth to get the clearest point; he finds it best at more than 14 inches from the eye, and we change the lens to +1.00; he can now read the finest type easily, and finds the best point at 14 inches from the eye. This is the proper reading lens for this eye, and we proceed to test the other by covering the left and trying the +1.00 with the right eye. He finds the best point at 14 inches, and he can easily read the finest type. Our prescription will read:

For Reading.

L. E. Spher. +1.00.

R. E. Spher. +1.00.

When a patient comes for reading glasses, always test for distant vision first whether glasses are wanted for distance or not. If distant vision is normal, then proceed to fit the reading lens as in the foregoing.

If there is hyperopia for distance, make a record of the plus lens required for distance, then the lens for reading can be fitted over that taken for distance and the sum of their combined value recorded as the correction for reading or the lens for distance may be removed and the fitting for reading may be done

the same as if distant vision be normal; but the reading lens will be required the amount of hyperopia stronger than would be required if the eye be normal for distance.

If there is myopia, then the reading lens required will be of less power than if the eye were normal for distance, and it can be fitted over the distant vision lens or not, as best suits the operator; but in any case, whatever the distant vision, or whether bifocals are to be ordered or not, the computation must be made and the prescription written for the reading lens just as wanted; or explain to the optical company how the correction is made and the prescription written, so they can make the proper computation.

If astigmatism is found, then, after making a record of the distant vision lens required, leave the cylinder in the frame just the same as for distance, and fit the spherical behind it to focus at the reading point, then record the combination for reading just as it is in the frame; except, if the cylinder is minus and the spherical is plus and of greater power than the cylinder, and the reading glasses are to be separate instead of bifocal, then the prescription can be transposed to make a more simple lens, as illustrated in case 9.

NINTH PAPER.

From the proportion of the foregoing cases that were fitted without drops, it might be inferred that their use is not advocated or practiced by the writer in a majority of cases. The cases given were each selected to demonstrate some particular phase of the subject, and a number of them happened to have been fitted without drops.

As stated in a previous paper, it is best to use drops in nearly every case under 40 years of age, and sometimes with those that are over 40. Often it is best to use atropine instead of homatropine, in order to get more profound and slower fading cycloplegia.

To show the writer's practice in the matter, one hundred cases under 40 years of age taken from his record book give the following result:

Number of cases in which drops were used, 65
Number of cases in which drops were not used 35

100

The writer's choice and advise would have been to use drops with many of the 35 cases fitted without them; but on account of the pa-

tients' wishes, or other reasons, they were not used.

Crossed Cylinders.

All cases of regular compound hyperopic astigmatism, and compound myopic astigmatism, should be fitted with a spherical and a cylinder, with the axis of the cylinder at right angles to the meridian requiring the greater degree of correction. Mixed astigmatism should also be corrected with a spherical and a cylinder, and the cylinder must be of the kind, either plus or minus, that requires the greater correction, and a spherical used for the lesser part; always bear in mind that with one convex and the other concave, the spherical exerts its full power in the meridian of the axis of the cylinder, but neutralizes in the cylinder the degree of its power in the meridian at right angles to said axis.

Crossed cylinders should not be used except in cases of irregular astigmatism, where the meridian of the greater degree of curvature, and that of the lesser degree, are not at right angles to each other. Such cases are rare.

The Fogging Method.

The fogging method of fitting is often of service where for some reason drops can not

be used, and also in proving the results of other methods. In this method one eye is covered with the rubber disk, and a spherical convex lens of sufficient power to cloud the vision from reading the largest letters on the test card is placed before the other eye. It will require a much higher power lens for this purpose with one who has a high degree of hyperopia than with one who has a lesser or different defect. After the high power lens has been before the eye a short time, the accommodating muscle will relax and assume a state of rest. Then concave lens of increasing power are placed over the convex fogging lens until enough of its power is neutralized to enable the patient to read the line for normal vision. The power of the convex lens left unneutralized will be the correction. When fitting astigmatism with the stenopaic disk without the use of drops, the fogging method can be followed by placing the convex fogging lens in the trial frame behind the stenopaic slit and then neutralizing each meridian in the same manner as in a spherical correction, and computing the difference as in the cases of astigmatism given in former papers.

By "Principal Meridians", is meant the one with the greatest, and the one with the least

curvature; they are usually at right angles with each other. The fogging method may be used at the initial testing, or it may follow testing by other methods to find if they agree, as tending to prove the correctness of the work. It will usually require a lens about +3.00 above any hyperopia that may be present to sufficiently fog the vision and put the accommodating muscle at rest.

Frequently a patient will be found whose vision can not be improved to near normal, and sometimes it can not be improved at all. The former is found at all ages, but most often from 40 to 65; and it is frequently due to Bright's disease; always make a urinalysis, together with other means of diagnosis, in such cases. Patients whose vision can not be improved at all are usually advanced in years, and the trouble is quite liable to be a cataract; frequently it is central and they give a history of better vision in a semi-darkness than in a bright light; this is due to a dilitation of the pupil beyond the area of clouded lens. Remember these troubles when vision can not be satisfactorily improved.

Strabismus.

It was stated in a former paper that the difference between insufficiency and strabismus is

one of degree, wherein the eyes are not able through increased innervation to maintain binocular fixation. The manifest squint may be a deviation of an eye inward, (Esotropia,) or outward, (Exotropia). It may be constant in one eye, called monolateral strabismus or, it may occur as alternating strabismus, in which sometimes one eye, and at other times the other eye deviates, while its fellow fixes the object.

Again the deviation may be constant, or it may occur only when the patient is excited or tired. The primary cause is nearly always ametropia; the secondary cause is insufficiency, and contributing causes may be fatigue, excitement, general debility or other systemic conditions.

Sometimes there will be a great difference in the refraction of the two eyes in strabismus, then again they may be nearly equal. Often there will be found great difference in the refraction of the two eyes, and there will be neither strabismus or insufficiency.

In any case the vision should be corrected with properly fitted lens, and any abnormal systemic condition treated. Then if there is insufficiency, give ocular gymnastics as follows:

Place a light twenty feet distant from a

chair, and at table height or more, and with a clear space for walking between the two. If one room is not long enough, use two rooms with the open door in line. Then fit a prism frame with prisms as strong as the patient can overcome and hold the light as one when within from three to five feet from it. Remember that the bases of the prisms must point away from the muscle that is to be exercised; for instance, to exercise and strengthen the internal recti muscles, the prisms would be placed in the frames bases out.

From some point near where the patient can see the light as one, the prisms are adjusted and the patient advances toward the light until it appears as one, then with the eye steadily fixed on the light slowly backs away until it appears as two, then lifts the frame and looks at the light a moment with the uncovered eyes. Repeat this exercise from three to six times the first sitting, and gradually increase the number of exercises at a sitting, as it can be done without fatigue to the eyes, until twenty or more are taken each time. There should be from one to three periods of exercises daily, depending on circumstances; the more taken the more rapid the progress. Continue the exercises with the prisms given until the patient can sit in the

chair twenty feet distant and the lights will immediately flash into one, or only one will be seen when first dropping the prisms over the eyes; then change for a stronger pair. The exercises should be continued until a pair of 20 or 30 degree prisms can be thus mastered.

Another way to exercise and strengthen the converging muscles, is to place some small object like a cork, on a stem like a wire, and beginning back some distance from the face, carry it slowly toward the bridge of the nose as far as the patient can see it. Then rest the eyes, and repeat several times at each sitting, and several sittings daily. This will answer at first, but it is not as good as prisms, nor will it take their place except in the beginning.

If one eye has lost its acuity of vision to any great extent, correct the refraction as accurately as possible, then give the blinder exercise daily as follows:

Cover the other eye with a pad or in the most convenient way, and compel the use of the nonfunctionating eye. Begin with a few minutes exercise and gradually increase its length daily. This will often rapidly restore function and acuity of vision, especially in a young person. The general health should be put into the best possible condition.

Where there is constant deviation, persistent efforts along the foregoing lines should be made and continued faithfully over a long period of time; then if not successful, tenotomy or advancement, as indicated, will probably be necessary for a cure, but this should be the last resort.

Asthenopia.

Patients will often complain of weak eyes; that they ache, or water and blur when used at near work. This is usually due to errors in refraction; but may be due entirely, or in part, to muscular insufficiency, excessive use of the eyes, neurasthenia, or other systemic condition.

At the same time there may be a conjunctivitis blepharitis, iritis, hordeolum, or other diseased condition of the eyeball or lids. This is especially liable to occur if the trouble is due to refraction. With a hypersensative nervous system, eyestrain may result in functional disturbance of any organ of the body, and in such disease as may be of nervous origin. People vary greatly in their sensitiveness to refractive error. An amount of error in refraction that one person would not mind at all, will be the cause of great disturbance in another person.

When a patient comes with asthenopia,

whether there is other disturbance or not, examine for, and correct any refractive error or muscular insufficiency, then limit the use of the eyes, give any indicated constitutional, local, or hygienic, treatment, and when using the eyes at near work rest them frequently by changing the vision to distant objects for a minute or two at a time.

Numbering Lens.

Under the old system of numbering lenses, one inch was taken as the unit and the lens was numbered according to its focal distance in inches. Thus a number 10 lens would focus parallel rays of light at a distance of 10 inches.

The new dioptric system of numbering is a metric system and takes for its unit one meter, equal to 39.37 inches, which for practical purposes and convenience in computing, when exact results are not required, may be called 40 inches; thus a lens to focus at 10 inches, one fourth of the unit distance, would have to be four times as strong, 4 diopters. A lens that has a focus greater than one meter is numbered in decimal parts of a diopter; thus one with a focus of 2 meters would be marked + 0.50 and one of 4 meters, + 0.25. A lens having a focal distance of less than one meter is numbered in multiples of the diopter and decimal

parts thereof, thus; one with a focus of ½ meter would be marked + 2.00, and one of ¼ meter, + 4.00. Always remember the decimal point, or you may get full diopters instead of decimal parts.

To change the old inch form of numbering into the metric form, divide the unit of the metric system by the number of focal inches indicated in the old style number, calling the meter 40 inches; thus: number 10 lens=40÷10=4 diopters, (+4.00). Number 20 lens=40÷20=2 diopters, (+2.00).

To change the metric system into the old style inch system, divide the diopter unit 40 by the diopter number; thus: 2 diopters =40÷2=20 inches, or number 20, and 4 diopters=40÷4=10 inches, or number 10. These results are not exact, but are approximately so, and near enough for practical purposes.

Neutralizing Lenses.

This is very important to be understood in order to be able to read a pair of glasses and know what a patient has been wearing, and to read those ground on your prescription and know that they are correct as ordered. This means is also used to prove that a transposed formula is the same in value as the original, as

mentioned in case IX; compound myopic astigmatism with separate reading glasses.

When the test letters, or other objects are viewed through a convex lens, and the lens moved sidewise to and fro, the letters or objects seem to move in the opposite direction from that in which the lens is moved; or as sometimes expressed, against the lens. When these objects are viewed through a concave lens and it is moved in the same manner, they seem to move in the same direction as that in which the lens is moved; or with the lens. If a convex lens and a concave lens of equal power are placed together they will just neutralize each other and there will not be any movement of the letters when thus viewed through them. This is the key to the neutralization of lenses. First view the letters through the lens and find if the movement is against or with the lens; then take lens of the opposite sign from the trial case and hold over it, finding the result on the movement each time; change until one is found that just neutralizes the lens and no movement of the letters take place with the movement of the lenses. The number of the neutralizing trial lens will be the number of the lens tested, but of opposite sign; thus: we view an object through a lens and find that it moves

against the lens; this shows it to be a convex lens, and we take a concave lens from the trial case and hold over it and find the movement still against the lens; we try one of higher power and find no movement, which shows that it is just neutralized; we look at the number of the neutralizing lens and find it to be — 2.50 hence the lens read is a + 2.50.

Again we want to read another lens and find that the movement is with the lens; this shows it to be a concave lens, and we try convex lenses from the trial case until we find one that just neutralizes it so that there is no movement; we then look at the number and find it to be + 1.75; hence the lens read is a —1.75. To read an astigmatic lens, its axis must be found, and then it can be neutralized with a cylinder of opposite sign with its axis parallel with the axis of the lens to be read, or a spherical of opposite sign may be used by moving the combination at right angles to the axis of the cylinder; if moved with the axis of the cylinder, the movement will be that due to the spherical alone.

To read a compound lens, find the axis of the cylinder and this will be the meridian of

least curvature; neutralize it and the power of the neutralizing lens, in opposite sign, will be the reading of the spherical part of the combination; then the meridian at right angles may be neutralized with a cylinder over the spherical, its axis parallel with the axis of the lens, and its number in opposite sign will be the reading of the cylinder part of the combination. Or the meridian at right angles may be neutralized with a spherical and the difference between the reading of the lens in this meridian and the meridian of least curvature will be the reading of the cylinder part of the combination.

There is a lens measure made with three projecting points, the center one movable and connected to an indicator on a dial; when a lens is pressed down firmly on the three points the curvature of the lens can be read on the dial.

Finding the Optical Center of a Lens.

When one looks through a convex lens at a straight edge or narrow strip that is longer than it covers, if not looking through the optical center of the lens, that part of the strip covered by the lens will appear to be displaced outward from the direction of its center. See Fig. 7, a-b.

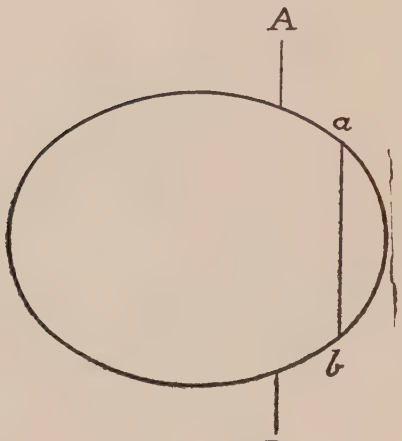


FIG. 7.

The strip must be narrow like the center piece of a window sash, a narrow frame, or a chair leg or spindle; and the eye must include a part of the strip outside of the lens.

The farther away the strip the greater the displacement; also the farther the line of vision from the center of the lens, or the stronger the lens, the greater will be the displacement.

As the lens is moved to make the line of vision pass through its center, the displaced part of the strip will move toward a line with the rest, and when it is in perfect alignment with the strip, see Fig. 8, a-b—A-B, then the

line of vision is through the axis of the optical center of the lens; mark a line across the lens to coincide with the strip A-B, then repeat the entire operation with the position of the lens turned at right angles, and obtain the line H-K Fig. 8; the point N where the two lines intersect, is the optical center of the lens.

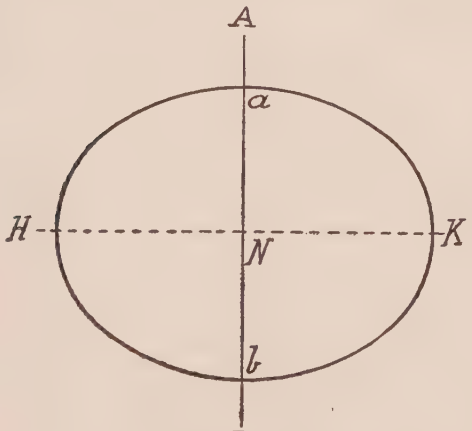


FIG. 8.

The optical center of a concave lens is found in the same way, but the part of the strip covered by the lens appears to be displaced toward its center instead of away from it; hence the lens has to be moved in the opposite direction from a convex one to bring the strip into alignment.

To Find The Axis of a Cylinder.

If one looks at a straight edge or narrow strip through a cylinder other than with its axis at right angles to, or parallel with, the strip, that part of the strip covered by the lens

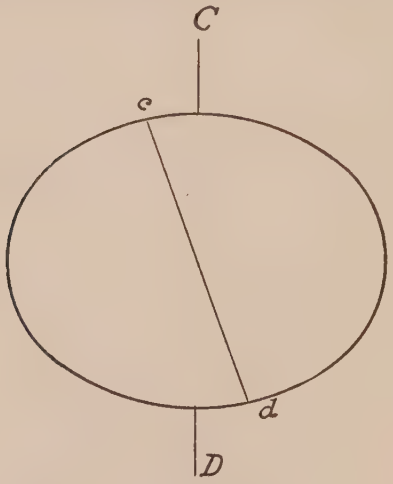


FIG. 9.

will appear oblique to that part of the strip seen above and below it. See Fig. 9, c-d. Rotate the lens to bring that part of the strip seen through it into alignment with that seen above and below, see Fig. 10, c-d—C-D; then a line marked across the lens to coincide with the

strip will be either at right angles to the axis of the lens, or parallel with its axis. Either will show a continuous line, but if at right angles to the axis that part seen through the lens will appear clear, and the same as that

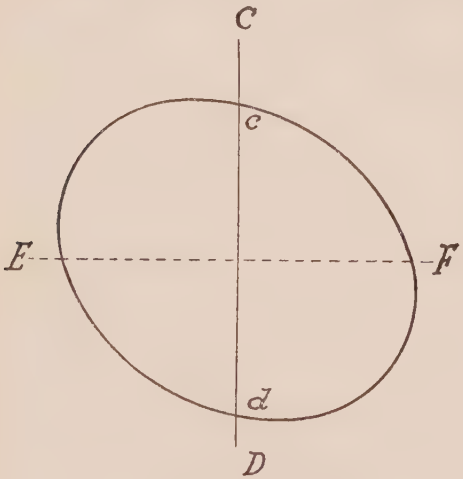


FIG. 10.

part above and below; while if parallel with the axis that part seen through the lens will appear larger or smaller than that part above and below, depending on whether it is a convex or concave cylinder.

With a spherical lens the displaced part of

the strip viewed through it moves against the lens if convex, and with it if concave; the direct movement would be the same with a cylinder; but when rotating a cylinder to bring the oblique part into line to find the axis, the displaced part moves with the lens if convex and against it if concave.

The entire phenomena in finding the optical center of sphericals, or the axis of cylinders, is due to the power that a prism has to deflect rays of light.

Size of Lens.

Lenses of any one manufacture are made to exact size in order to be interchangeable, and are usually designated as 2 eye, 1 eye, 0 eye, 00 eye, thus increasing with an extra 0 for each next larger size. A lens for a frame has a beveled edge, while the edge of a rimless lens is not beveled; the size of a rimless lens is nearly the same as the lens and rim of the same number in a frame. In writing for a lens, the size of the person, size of the face, and the pupillary distance have to be considered in deciding as to the size that will be most becoming. At present 0 eye size is generally worn; a child would usually take 1 eye size, and a very small child 2 eye; while a very large person with a broad face and wide pupillary distance might

want 00 eye. The same number for size would need to be given whether they be for frames or rimless. The same is true of eye glasses.

Where glasses are to be worn constantly, or where there is any astigmatism, the oculist should discourage the use of eye glasses, and try to persuade the patient to wear temples to hook over the ears. An eye glass has no outside stay, and the tremble that is sure to occur to a more or less extent, has a similar effect on the wearer of them that reading on a moving train would have. Then if there is astigmatism present the axis should be placed and maintained in the right meridian; this is very difficult to do with an eye glass.

There is very little difference in the medical aspect of the case, whether frames or rimless glasses are worn; occasionally a nervous patient will be annoyed by the rims on glasses with frames. Rimless glasses are right in every way except their liability to get broken. The occupation of the patient with a view to the liability to breakage, and the earning capacity, or ability to buy new lens, should be considered in deciding whether to wear frames or rimless.

Measuring for Frames.

In cities where the prescription is taken to

the optician by the patient in person, the measurements for the frames, or fittings, may be taken by the optician; but where the oculist sends for the glasses for the patient, or the patient sends the prescription by mail, it is important that the oculist make accurate measurements, and write the prescription in detail for the frames or fittings.

A good correction with lens might be entirely negatived by an improperly fitted frame. This is especially true where there is astigmatism. Three important points are, pupillary distance, height of lens, and distance from the eye.

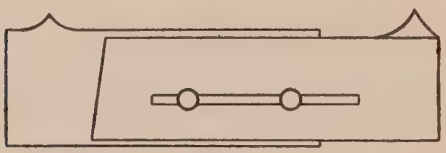


FIG. 11.

The pupillary distance is the distance from center to center of the pupils, and may be found by having the patient sit directly in front of the operator, and look steadily at the bridge of his nose; then measure the distance with a rule; or two pieces of cardboard may be cut with a point on each, and with a slot through one of them, and holes through the

other, through which they are fastened together with paper fasteners so they may be adjusted for distance. See Fig. 11.

Hold the points in line with the eyes and slide the cards to bring them to coincide with the pupils; then measure the distance between the points.

The ordinary distance is 2½ inches; occasionally one will be found 2⅞, often one 2⅜ and sometimes one 2¼. The height of the bridge should be such that a line passing through the optical center of the lens at right angles will strike the patients pupil. It is found by measuring from a line passing through the optical center of the lenses from temple to temple, to the crest of the bridge; it usually runs from 1-16 to 1-4 inch.

If the oculist's outfit contains the three measuring frames mentioned in paper one, try frames until one is found that sets the lens at the right height, then measure it.

The lens should set as close to the eyes as possible and not touch the lashes; where the patient has very long lashes it is sometimes advisable to clip the longest, in order to set the lens closer than could otherwise be done. This distance is controlled by setting the crest of

the bridge on a line with, or back of, or in front of a line with the plane of the lenses. Setting the crest back will move the lens farther from the eye; try measuring frames until the right one is found, then measure from a line with the plane of the lenses to the crest of the bridge.

The crest must be at the proper angle in order to rest comfortably on the nose; the measure is taken with the crest measure mentioned in the outfit, paper one; directions for using will be found on the back of the measure.

The width of the bridge at its base should be given, and may be found by measuring a bridge that fits the patient.

The temple space should be such that the temples will rest lightly against the face, and thus help to steady the lens.

Temple length should also be given; the usual length of a riding bow is 5½ inch for a child and 6 inch for an adult.

Prescription blanks furnished by optical houses have the various measurements designated with spaces to insert the figures; they are also arranged for the lens prescription.

Prescription Writing.

The cases given in these papers indicate a plain way to write the prescription. The following forms are different ways for writing for the same thing, and there are other forms slightly different.

L. E. Spher. + 1.00 Cl. + 0.50 Ax. 90.

O. S. S. + 1.00 = C. + 0.50 Ax. 90.

O. S. + 1.00 Spher. = + 0.50 Cyl. Ax. 90.

If for the right eye it would be R. E. or O. D. in each case.

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